

CANOTIA VOLUME 19

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Canotia is named for *Canotia holacantha* Torr. (Celastraceae), a spiny shrub or small tree nearly endemic to Arizona. Cover illustration by Alandon Joe.

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INDEX TO FAMILIES OF THE VASCULAR PLANTS OF ARIZONA

Published treatments (**in bold**) can be found in volumes 26, 27, 29, 30, 32, 33, and 35 of the *Journal of the Arizona-Nevada Academy of Science* (JANAS) or in subsequent volumes (1–19) of **CANOTIA**. Unbolded entries indicate families with no treatments published to date. Figure numbers refer to illustrations in the “Key to Families of Vascular Plants in Arizona” in JANAS 35(2). All Vascular Plants of Arizona treatments are available as pdf files online at (https://canotia.org/vpa_project.php).

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REVISITING THE FLORA OF WHITE TANK MOUNTAIN REGIONAL PARK

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ABSTRACT: White Tank Mountain Regional Park is a 12,140-ha desert mountain preserve on the western edge of the Phoenix metropolitan area. A floristic study of the park was conducted by David Keil from 1968 to 1970 as a graduate student thesis project, and formally published in 1973 as "Vegetation and Flora of the White Tank Mountain Regional Park," the first detailed accounting of the park's flora. We here report a new floristic inventory of the park, conducted between 2016 and 2022 and compare the data sets from the two surveys. Our survey documents 327 vascular plant species, including 43 previously not known to grow in the park. The number of non-native species has increased from 20 to 29 since 1968; 31 previously unreported native species were found; 63 species, native and non-native, from the prior study were not encountered. We discuss environmental changes that have occurred in the last 50 years in local climate, land and groundwater use, and fire that may explain changes in species composition.

INTRODUCTION

White Tank Mountain Regional Park (WTMRP), northwest of the city of Phoenix, Arizona, was created as part of Maricopa County's park system in 1961. At 12,140 ha (nearly 30,000 acres), it is the largest regional park in Maricopa County (Maricopa County Parks and Recreation [MCPR], 2014a). In 1968, Arizona State University graduate student David Keil began work on a flora of the new park as part of his Master of Science degree (Keil 1970), which he later published as the "Vegetation and Flora of the White Tank Mountain Regional Park" (Keil 1973). Until this plant inventory (the Keil flora), few plant collections had been made in the area, so the park's flora was poorly known. Keil collected 1148 plant specimens that documented 332 vascular plant species (Keil 1973).

Today, the floristic diversity of WTMRP faces several challenges due to the development of roads, parking areas, trails and facilities to accommodate a growing number of visitors. Urban development is planned to surround the mountains and isolate it from nearby natural areas (White Tank Mountains Conservancy [WTMC] 2021). Additionally, several non-native species have arrived since the Keil flora, a few of which are beginning to dominate in some areas of the park.

In 2016, the Central Arizona Conservation Alliance commissioned a new floral inventory (the Blodgett-Goldman flora, or B-G flora) to generate an updated plant checklist for the park. In this paper we present data from our survey and make comparisons with the Keil flora to highlight changes that have occurred in the last 50 years.

STUDY AREA

WTMRP is at the northern boundary of the Sonoran Desert in Arizona and lies just west of the greater Phoenix metropolitan area (Figure 1). It covers part of a larger (ca. 32,000 ha) north-south trending mountain island in the Phoenix Basin (Henderson et al. 2020). The elevations in the park range from 411 m (1350 ft) on the south-east corner on the alluvial apron surrounding the mountains to 1244 m (4083 ft) on the highest peak.

GEOLOGY

The White Tank Mountains are a metamorphic core complex of Proterozoic rocks (1.7 bya) intruded by two late Cretaceous to early Tertiary aged granitic plutons. The range is surrounded by Quaternary alluvium from early Pleistocene to present (Reynolds 2002). The soils in and around the mountains are derived from the mountains' metamorphic and igneous rocks.

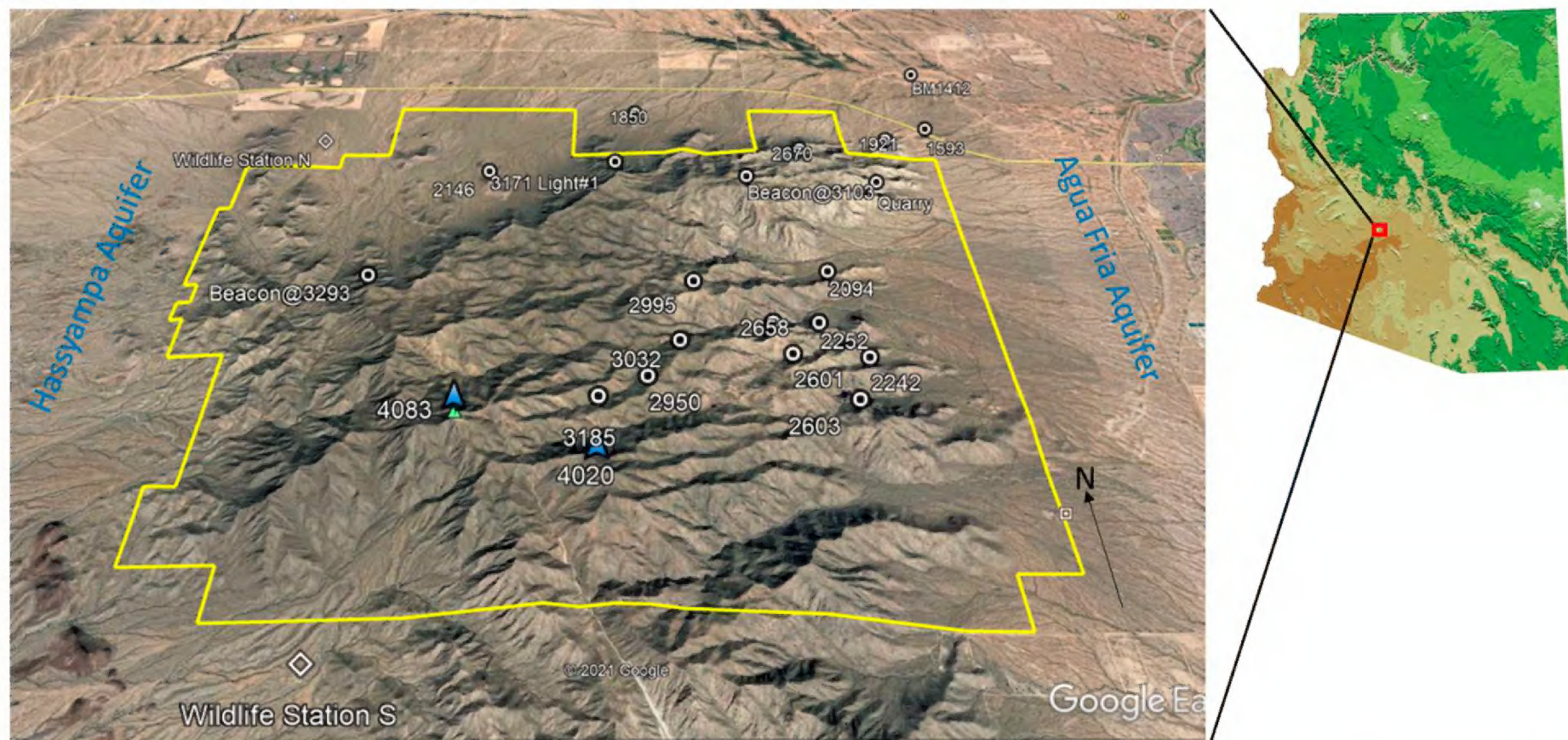


Figure 1. Map of White Tank Mountain Regional Park. Satellite imagery from Google Earth was used to create the figure.

The west side of the mountains is part of the Hassayampa River watershed. It rises abruptly from the desert floor and features rough, rocky terrain with thin soils. The east side of the mountains is part of the Agua Fria River watershed and rises more gradually from the valley floor. It contains areas with deeper soils, some of which can temporarily hold water from wetter seasons and features at least two permanent springs. The north end of the mountains is also abrupt but rises from sandy Creosote Bush (*Larrea tridentata*) flats that generally drain to the east and into the Agua Fria River watershed. The southern boundary of the park cuts across the mountain range, which continues to the south and meets the valley floor near Interstate Highway 10.

HISTORY

When the park was established, an archeological survey discovered several prehistoric sites, including some with rock art and artifacts. The rock art is mostly attributed to the Hohokam people, who occupied the area between 500 AD and 1100 AD, with some attributed to the Western Archaic people who preceded the Hohokam. The Western Yavapai people controlled the area more recently (Rasmussen 2014).

REVISITING THE FLORA OF WHITE TANK MOUNTAIN REGIONAL PARK

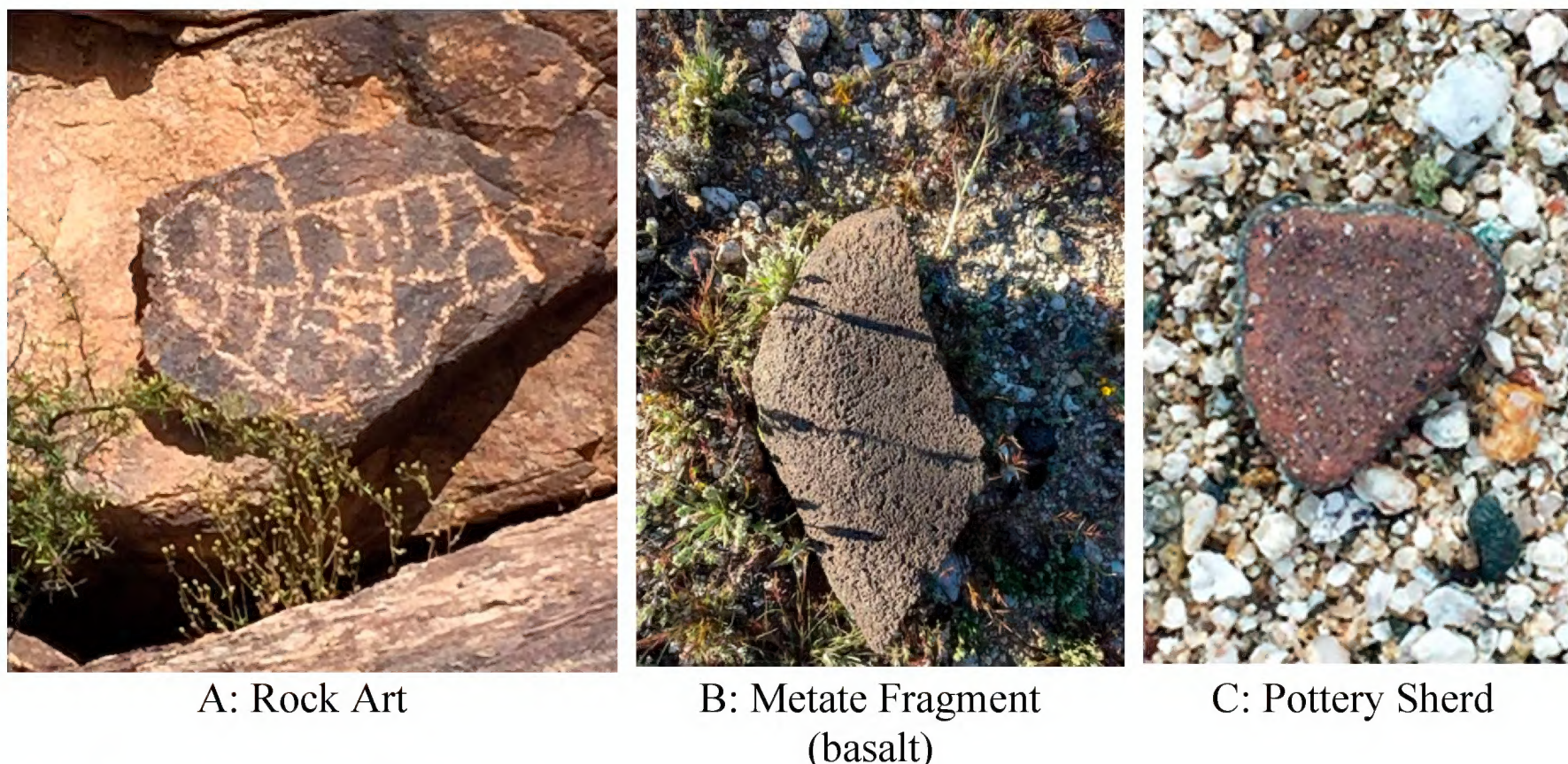


Figure 2. Evidence of Past Land Use.

Prior to the completion of a rail route from Phoenix to Prescott in 1895, the White Tank Wagon Road followed a series of wells and watering holes from south of the Gila River to Prescott. One of these was a natural water tank in the northeast part of the mountains that offered year-round water. This “white tank” became the namesake of the mountains (MCPR 2014b).

From the late nineteenth to mid-twentieth century more than 100 mining claims were filed. However, there is no evidence of significant production from any mines. Roughly during the same period, the mountains supported ranching operations with goats, sheep and cattle. Evidence of the ranching history of the mountains, thought to have ended in the 1930s, can still be found throughout the range, and stray cattle sometimes wander into the park (MCPR 2014b).

During World War II, navigational beacons were installed on several peaks. Evidence of these and their later conversion from battery to powerline sources is still present (MCPR 2014c).

Several of the highest peaks support antenna farms. In July 1993 equipment used to service the antennas ignited a fire and burned 1214 ha (3000 ac) in the northeast quadrant of the park (MCPR 2014d).

CLIMATE

The US Climate Normals for 1991–2021 reports the following for the Phoenix area: the average annual temperature is 75.6°F (24 °C) with an average annual high of 87.1°F (31 °C) and an annual average low of 64.1°F (18 °C). The hottest month is July with an average high of 106.5°F (41 °C) and the coolest month is December with an average low of 45.3°F (7 °C) (National Weather Service [NWS] 2021a).

Rainfall near the northern edge of the Sonoran Desert is bimodal, having peaks in both winter and summer and with winter typically delivering about two-thirds of the annual rainfall. Average annual precipitation is 7.22 in (183 mm). Peak rains fall from the months of December through March and from July through August (NWS 2021a). Fall and late spring are typically drier and windy. Annual rainfall can be highly variable year to year. In seasons of greater than

average rainfall, annual plants may dominate the landscape. However, it is common for there to be so little rain in either the winter or summer peaks that few, if any, annuals germinate.

For much of the flora of WTMRP, growth and flowering is triggered by winter rains. A subset of the park's plants can respond to both winter and summer rains, and a smaller but distinct cohort of the flora responds only to the summer monsoon rainfall.

VEGETATIVE COMMUNITIES

The vegetation of WTMRP falls within two of the major subdivisions of the Sonoran Desert described by Forrest Shreve (Brown 1994). The Lower Colorado River Valley subdivision describes the plant community and distribution on the flats surrounding the mountain slopes. Where the flats meet the slopes of the mountains, the plant community immediately transitions to the Arizona Upland subdivision, which continues upslope to the peaks.

Within these divisions, several series as defined by Brown (1994) can be recognized, but not very distinctly, as they intergrade with one another. The Lower Colorado River Valley subdivision is predominantly represented by the Creosote-Bursage and Mixed Scrub series. The Arizona Upland subdivision is best represented here as the Palo Verde–Mixed Cactus Scrub series below 853 m (2800 ft) and a mix of other higher elevation series above 853 m.

Departing from Brown's definitions, a more detailed picture of the plant communities and habitats of WTMRP can be formed by adapting and extending the zones of vegetation Keil employed to partition the habitats and floral communities of the park. To this end we identified eight distinct habitat types with characteristic plant assemblages. These are:

- Alluvial Plain Desert Scrub
- Upper Sonoran Desert Scrub
- Desert Grasslands
- Sheltered Sites
- Drainages and Canyons
- Springs
- Constructed Wetlands
- Secondary Succession Landscape (from fire)

Alluvial Plain Desert Scrub. Alluvial Plain Desert Scrub occupies the gentle slopes leading from the park boundaries to the steeply rising slopes of the mountains. *Larrea tridentata* and *Ambrosia deltoidea* dominate much of this community. *Parkinsonia microphylla*, *Olneya tesota*, and *Encelia farinosa* are occasional on the flats but are more common in the shallow drainages. On the west side of the mountains, *Prosopis velutina* occasionally joins this cohort of trees, and *Ambrosia dumosa* replaces *A. deltoidea* on coarser substrates. *Carnegiea gigantea*, *Cylindropuntia acanthocarpa*, *Cylindropuntia bigelovii*, and *Ferocactus cylindraceus* are the most common cacti.

There are occasional areas of desert pavement that are only sparsely populated, usually with annuals in such genera as *Chorizanthe*, *Cryptantha*, *Pectocarya*, *Chaenactis*, *Plantago* and *Erodium*, and even fewer perennial shrubs and trees. Plants on this substrate achieve only diminutive form compared with their size in other habitats.

REVISITING THE FLORA OF WHITE TANK MOUNTAIN REGIONAL PARK

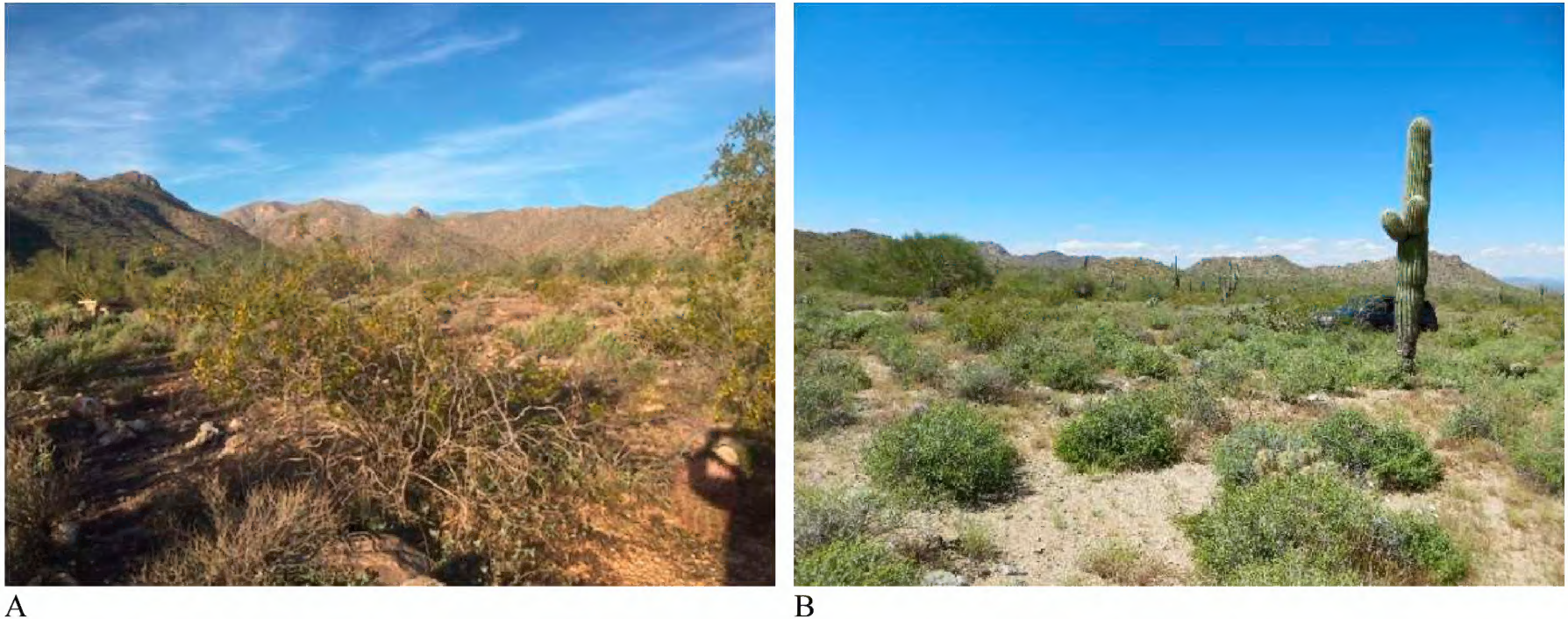


Figure 3. Alluvial Plain Desert Scrub. (A) Alluvial plain on the eastern side of the range. *Larrea tridentata* is in the foreground with *Olneya tesota*, *Encelia farinosa*, and *Parkinsonia microphylla*. (B) Alluvial plain on the north side of the range. *Ambrosia deltoidea* dominates with scattered *Carnegiea gigantea*, *Larrea tridentata*, and *Parkinsonia microphylla*.

Upper Sonoran Desert Scrub. Upper Sonoran Desert Scrub occupies the rocky slopes from the base of the mountains at 442 m to 884 m (1450 ft to 2900 ft), making it the largest plant community in the park. The dominant plants here are *Parkinsonia microphylla*, *Olneya tesota*, *Senegalia greggii*, and *Fouquieria splendens*, which provide the upper story. A wide variety of shrubs are present but *Encelia farinosa*, *Lycium* spp., *Sphaeralcea ambigua*, and *Krameria bicolor* are ubiquitous, as is *Bahiopsis parishii* on north-facing slopes. On north-facing slopes, *Simmondsia chinensis* often replaces *Larrea tridentata* as a middle story shrub. *Cylindropuntia bigelovii* is common on south-facing slopes and is scattered on some of the flats below the mountains, but is usually absent from other slope aspects.

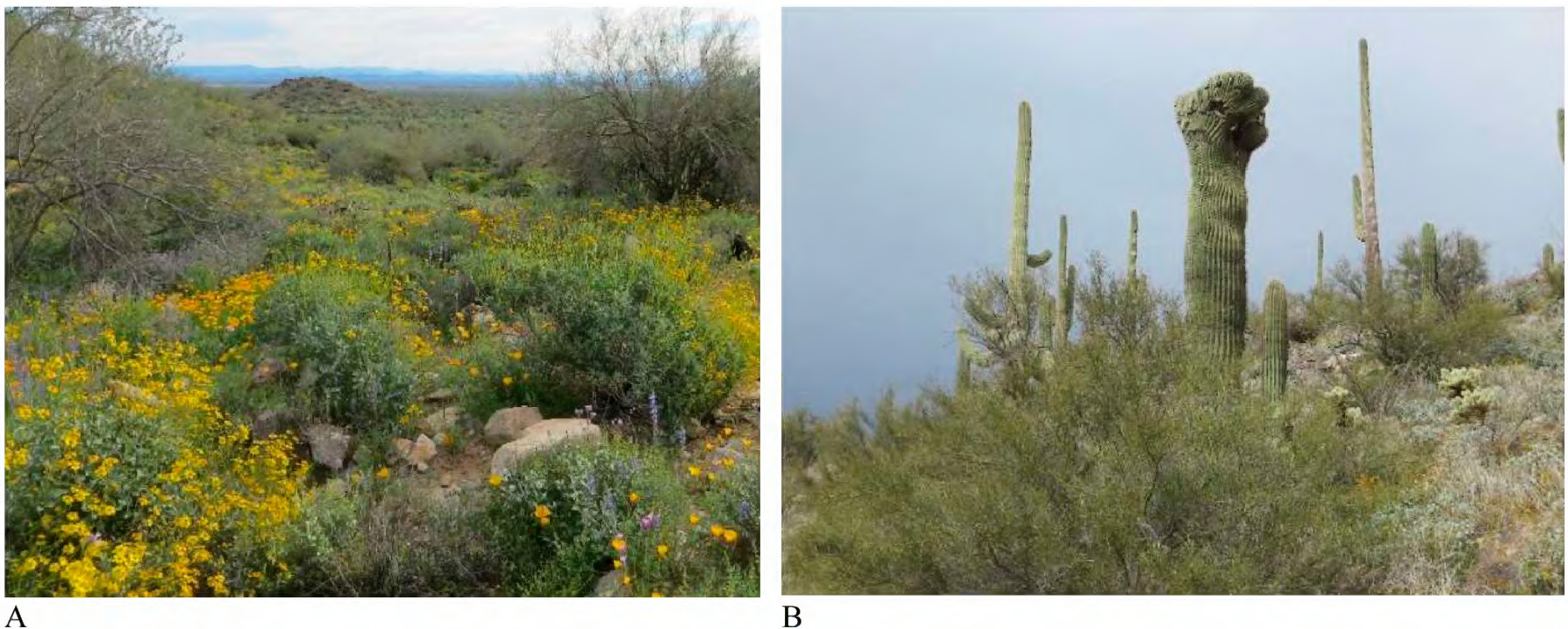


Figure 4. Upper Sonoran Desert Scrub. (A) A typical spring assemblage with *Encelia farinosa* and *Olneya tesota* in bloom with *Ambrosia deltoidea*, *Parkinsonia microphylla*, *Eschscholzia californica* subsp. *mexicana*, *Lupinus sparsiflorus*, and *Phacelia cremulata*. (B) A slope at the upper edge of the bioregion with a southern aspect. *Cylindropuntia bigelovii* appears with *Carnegiea gigantea* (including crested example in foreground), *Parkinsonia microphylla*, *Encelia farinosa*, and *Fouquieria splendens*.

Desert Grasslands. Desert Grasslands occur at higher elevations from 853 m (2800 ft) to the mountain-top at 1244 m (4083 ft). *Hilaria rigida* and *Aristida purpurea* var. *nealleyi* are the main bunchgrasses that make up this grassland. *Cirsium neomexicanum* is frequent in this community, as is *Calliandra eriophylla*. *Canotia holacantha* and *Agave simplex* can only be found in this community on north-facing slopes. At these higher elevations, *Melampodium leucanthum* and *Psilostrophe cooperi* are occasional caespitose shrubs and *Krameria erecta* replaces *Krameria bicolor*. Rocky outcrops support occasional *Penstemon subulatus*. None of these plants occur below this zone. For slopes with Southern exposure, *Bromus rubens* often dominates the space between shrubs.

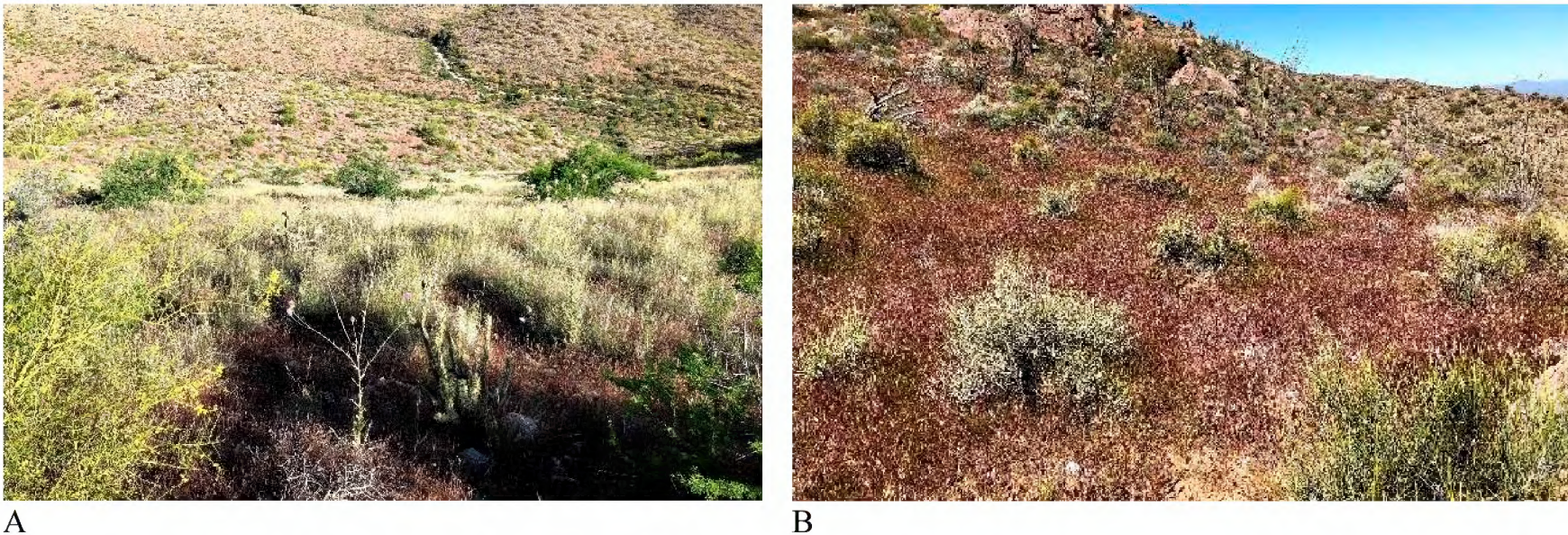


Figure 5. Desert Grassland. (A) Valley at ca. 880 m (2900 ft) with north-west aspect. *Hilaria rigida* carries down to the bottom of the valley with *Bromus rubens* in the foreground, along with *Cirsium neomexicanum* and *Cylindropuntia acanthocarpa*. *Parkinsonia microphylla* is the foreground tree and *Senegalia greggii* is in the background. (B) Slope with south-east aspect. *Bromus rubens* dominates with *Ephedra* spp., *Ferocactus cylindraceus*, and *Fouquieria splendens*. *Canotia holacantha* is barely visible on ridgeline.



Figure 6. Desert Grassland. (A) Slope above 850 m (2800 ft) with north-facing aspect. *Canotia holacantha* with *Cylindropuntia acanthocarpa*, *Encelia farinosa* and *Ambrosia deltoidea*. *Bromus rubens* is in the foreground. (B) *Agave simplex* with *Cylindropuntia acanthocarpa*, *Parkinsonia microphylla*, and *Bromus rubens* with *Delphinium parishii* in the foreground. (C) *Penstemon subulatus* may be found in crevices of rocky outcrops of the upper elevations.

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Sheltered Sites. Sheltered sites at the bases of abrupt, high cliffs with a northern exposure, provide extended shade throughout the day and may also provide seasonal water seepage to the soils protected by these cliffs. These sites support *Celtis pallida*, *Keckiella antirrhinoides*, *Artemisia ludoviciana*, and *Salazaria mexicana*. Smaller sheltered sites such as rock overhangs and grottos harbor *Galium* spp., *Delphinium* spp., ferns (Pteridaceae), *Dudleya arizonica* and *Boechera perennans*. Many of the plants found at these specialized sites do not occur elsewhere.

Drainages and Canyons. Six major drainages and canyons on the east side of the park carry runoff toward the Agua Fria River. These drainages can be divided into their xeric and mesic segments. The xeric segments, usually at lower elevations, feature nearly barren sandy bottoms due to occasional flash floods, but their loamier banks harbor *Prosopis velutina*, *Olneya tesota*, *Hyptis emoryi*, *Trixis californica*, *Ambrosia ambrosioides*, *Salazaria mexicana*, *Senegalia greggii*, and *Simmondsia chinensis*. Mesic segments of the major drainages are usually found in an elevation window between 609 m and 732 m (2000 ft and 2400 ft). Their soils retain moisture after rain events and may feature seeps at canyon wall bases but do dry out in the warmer season. They may feature *Erythranthe guttata*, *Tamarix chinensis*, *Cynodon dactylon*, *Juncus bufonius*, *Polypogon monspeliensis*, *Hordeum murinum*, *Aristida purpurea* var. *nealleyi*, *Cenchrus ciliaris* and *C. setaceus* in addition to many of the plants found in the xeric segments.

Springs. There are two springs with year-round water that support the park's only populations of *Salix gooddingii*. Additionally, *Prosopis velutina*, *Ambrosia ambrosioides*, *Brickellia coulteri*, and *Abutilon incanum* occur at these springs but are also common occurrences elsewhere in the major drainages. The other plant, aside from *Salix gooddingii*, that is conspicuous at these springs is a thick covering of *Cynodon dactylon*, the common perennial used in residential lawns known as Bermudagrass.

Constructed Wetlands. Constructed wetlands in the park have been made by creating earthen dams across shallow drainages and building levees on the sides to impound water after rain events. These may have preceded the park's establishment during its ranching history as livestock watering tanks, but they now are apparently maintained, and some are augmented with artificial water supplies to support the park's wildlife. They feature fine, silty substrates and are dominated by the introduced annual grass *Hordeum murinum*.

Secondary Succession Landscape. A large secondary succession landscape was created in 1993 when the Bug Fire burned 2430 ha (6000 ac) in the northern half of the mountain range. Parts of the burn area are nearly devoid of upper and medium story plants such as *Parkinsonia microphylla* and *Lycium* spp. that are otherwise ubiquitous throughout the park. *Encelia farinosa* is the dominant shrub in most of these patches and forms near monocultures in a few areas such as the southern exposed slopes along the Mesquite Trail. Where the higher elevations burned, *Bromus rubens*, an introduced annual grass, can dominate the landscape, especially on southern exposures.



A



B



C



D

Figure 7. Sheltered sites. (A, B) Large Scale. A) Steep, north-facing slope with large boulders forming shelter needed for *Keckiella antirrhinoides* to thrive. B) Tall, north-east facing cliff face shelters *Celtis pallida* and *Quercus turbinella* with *Senegalia greggii*. (C, D) Small Scale. C) Base of near-vertical, north-facing slope with large rocks prolongs soil moisture for *Delphinium scaposum* to grow with *Phacelia distans*, *Cottisia gracilis* and *Bromus rubens*. D) *Dudleya arizonica* requires the partial shade of steep, north-facing slopes, or the shade provided by rock overhangs, seen here with *Echinocereus engelmannii*.

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A



B



C



D

Figure 8. Drainages and Canyons. (A, B) Drier segments. A) Typical xeric segment of a major drainage featuring *Prosopis velutina* with *Parkinsonia microphylla* as well as *Olneya tesota* and *Senegalia greggii*. B) Both the xeric and mesic segments of major drainages can be thick with *Cenchrus ciliaris* and/or *Cenchrus setaceus*. (C, D) Wetter segments. C) Mesic segments of major drainages like this one usually support *Tamarix chinensis* with *Cynodon dactylon* and *Hordeum murinum*. D) *Erythranthe guttata* is found only in drainages with soils that hold water for extended periods of time like this wet crevice.



Figure 9. Springs and Constructed Wetlands. (A) Black Canyon Spring in WTMRP. In the foreground is *Cynodon dactylon* with *Prosopis velutina*, *Ambrosia ambrosioides* and *Salix gooddingii* in the background. (B) One of the constructed wetlands in WTMRP featuring a wildlife watering tank. *Hordeum murinum* covers all the interior with *Prosopis velutina* and *Olneya tesota* on the levees.



Figure 10. Fire Succession Landscape. (A) Remains of *Carnegiea gigantea* with other burn-scarred examples in background with *Ambrosia deltoidea* and *Lupinus sparsiflorus*. (B) Burn-scarred *Ferocactus cylindraceus* with *Encelia farinosa*, *Lupinus sparsiflorus*, *Senegalia greggii*, and *Ambrosia deltoidea*. *Bromus rubens* densely fills the space between plants. (C) *Encelia farinosa*-dominated areas without upper story plants are typical of the burn area. (D) *Calochortus kennedyi* is frequent in the burn zone but not often encountered outside of it.

METHODS

Sixty-two collection trips were made to the park between February 2016 and October 2022. Collections were made in all months except July.

Nearly all travel in the park was on foot. Most collection sites were near hiking trails or in the drainages on the eastern and northern slopes of the mountains. More difficult-to-access locations were selected based on our estimate for the sites' potential of harboring unvouchered species. Google Earth was used extensively to reconnoiter the study area and identify sites for visitation.

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Collections were limited to vascular plants. All collections were deposited in the herbarium of Desert Botanical Garden (DES) in Phoenix. Most plants were identified using Arizona Flora (Kearney et al. 1960). Additional taxonomic treatments used include Vascular Plants of Arizona Project (Vascular Plants of Arizona Editorial Committee 1992+), Flora of North America (Flora of North America Editorial Committee 1993+), and eFloras (2009). Grasses (Poaceae) were identified using Barkworth et al. (2007) as the principal reference. Confirmations of plant identification were made by comparison with reference herbarium specimens at DES. Native vs. non-native classifications adhere to USDA Plants Database (United States Department of Agriculture 2021), with the exception of *Matthiola parviflora*, which is not included in the USDA list for Arizona but is an introduced species (Horst et al. 2014). Scientific names conform to SEINet's Central Taxonomic Resource with few exceptions (i.e. genus *Cenchrus* instead of *Pennisetum*, and *Senegalia* and *Vachellia* instead of *Acacia*).

A checklist of plants present around the time of Keil's study was assembled using herbarium specimens recorded in the Southwest Environmental Information Network database (SEINet 2013). These records include Keil's vouchers and those of all other collectors who made sporadic collections in the area from 1932 through 1976. Subsequent to these collections, few others were made, but no new plants were added to the known flora until our work. Based on these data, the baseline flora ca. 1968 is 357 species and infraspecific taxa. The checklist, including links to all voucher records, is available to the public on SEINet ([White Tank Mountains Regional Park 1968](#)). This superset of the list presented in Keil's 1973 publication is what we refer to going forward as the Keil flora.

A checklist for the B-G flora was also created, with links to all of our vouchers, plus those of any contemporary collectors made between 2016 and 2022 and is publicly available on SEINet ([White Tank Mountains Regional Park 2016](#)).

Additional searches were made of databases including SEINet (SEINet 2013), GBIF (GBIF: The Global Biodiversity Information Facility, 2020), and iNaturalist (INATURALIST) for recent collections and observations of plants in and near the park boundaries, that were not encountered in our fieldwork. These were evaluated for inclusion into the B-G checklist.

RESULTS AND DISCUSSION

We present the findings from our fieldwork, compare our data with a similar survey done over 50 years ago and look for indications of changes that have occurred.

Over the course of our 62 collection trips, 1200 specimens were collected including 327 vascular plant species in 63 families.

Figure 11 shows our plant checklist accumulation approximating a logarithmic curve. At collection trip 62 our accumulation rate is about 1.4 new plants per trip. So, while additional collecting trips are projected to still increase the checklist, the effort for each addition is increasingly high.

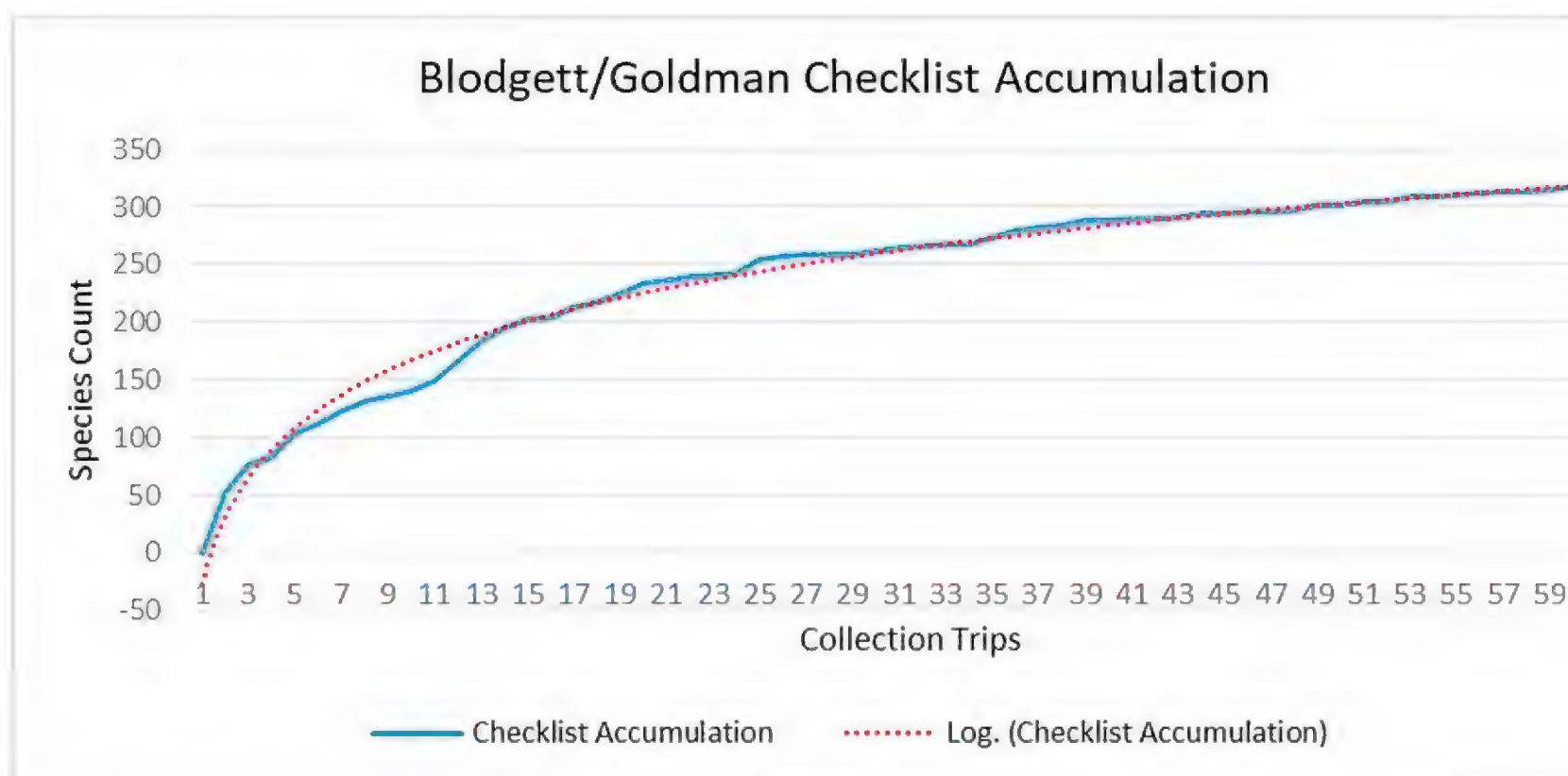


Figure 11. Species accumulation curve showing rate of collections of new plants approximating a logarithmic curve.

Figure 12 shows the collection region with a red marker at each site where one or more vouchers were taken during the present study, precision afforded by the use of a GPS device. Such precision was difficult to obtain prior to the advent of GPS, and field notes prior to the GPS era often did not include precise coordinate data. For this reason, a map of exact collection sites for the Keil flora is not possible, so an approximation of the region collected then is shown in Figure 12 with a cyan colored polygon. The region was estimated by analyzing all the labels from Keil flora vouchers, making a best effort to estimate the focus of those collections, and drawing an enclosing polygon on the map.

It is evident that the southern end of the park was covered more by the B-G flora and the northern end of the park was covered more by the Keil flora. Despite these differences, the areas of coverage for the two studies are similar, making comparisons appropriate.

A few important facts are evident from a simple side by side comparison of basic collection data between the Keil and B-G floras (Table 1).

First, the number of introduced species in the park has increased from 20 to 29, however the composition has changed between the two floras (Table 4). Second, 43 species collected in the B-G study were not previously known in the park. Third, 64 species from the Keil flora checklist were not encountered during this study.

The plant family represented by the most species in WTMRP is the Asteraceae family, followed by Poaceae, Boraginaceae, Fabaceae, Malvaceae, and Cactaceae (Figure 13). Together these six families comprise more than 50 percent of the species in the park.

The flora of WTMRP is almost exactly half annual and half perennial, as measured by both the Keil and B-G studies. Most of the vascular plant species (52.5%) in WTMRP are herbaceous (Figure 14). Herbaceous plants include all the annuals as well as a subset of the perennials that have no woody parts, such as geophytes (e.g., *Dichelostemma* and *Delphinium*). Ferns include *Pteridaceae* and *Selaginellaceae*. Graminoids (12.3%) are all the *Poaceae* but include one species from each of *Cyperaceae*, *Juncaceae*, and *Typhaceae*. Succulents (4.9%) are all the *Cactaceae* and *Crassulaceae* plus one species each from the genera *Bursera* and *Agave*.

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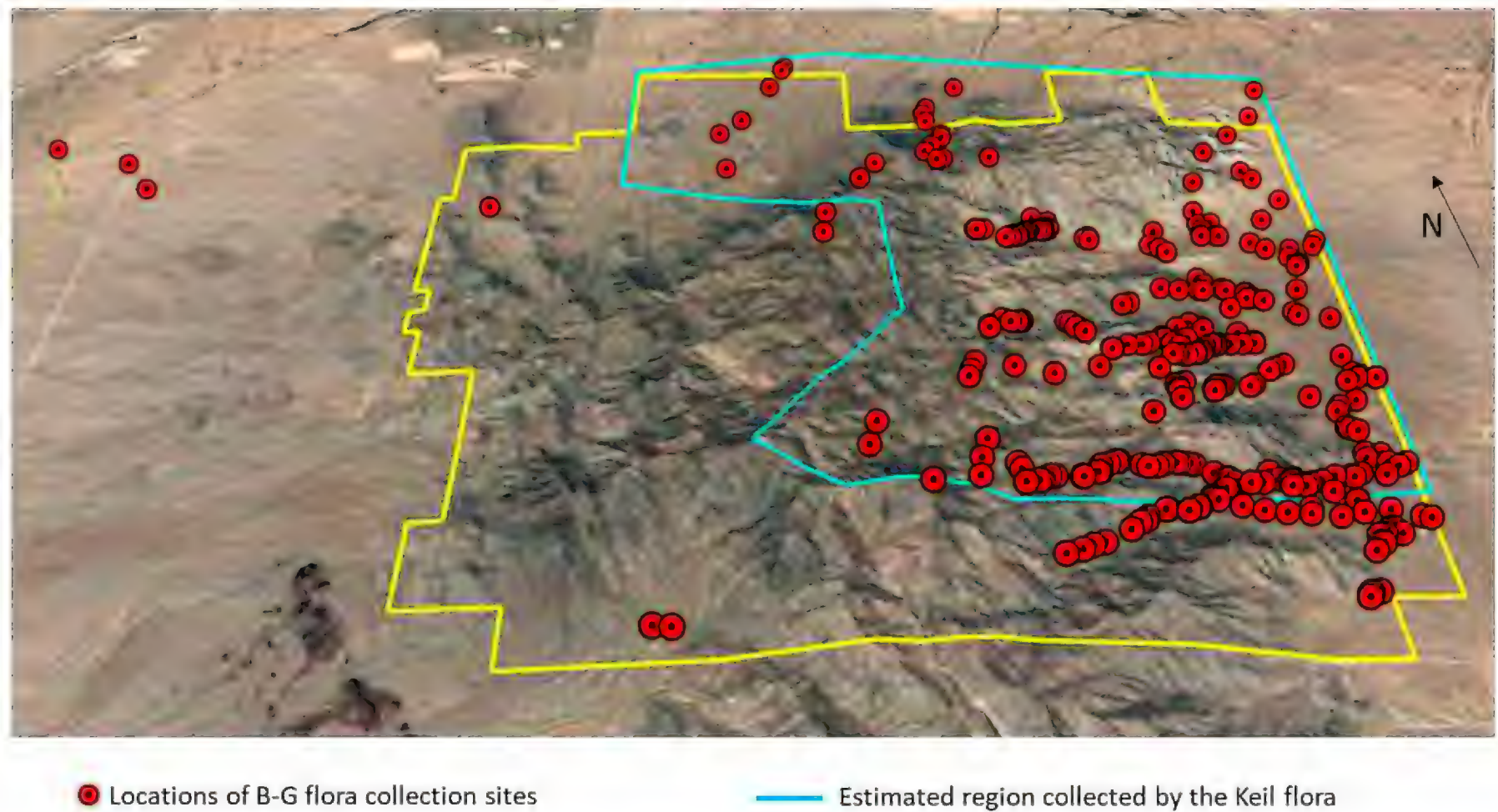


Figure 12. WTMRP boundaries outlined in yellow. B-G flora collection sites are marked with red spots. The estimated region collected by the Keil flora is outlined in cyan. Satellite imagery from Google Earth was used to create the figure.

Table 1. Basic Collection data from the Keil and B-G floras.

Measure	Keil Flora	B-G Flora
Plants Collected	1148	1241
Vascular Plant Species	357	327
Introduced Species	20	29
Added Species	NA	43
“Missing” Species	NA	64

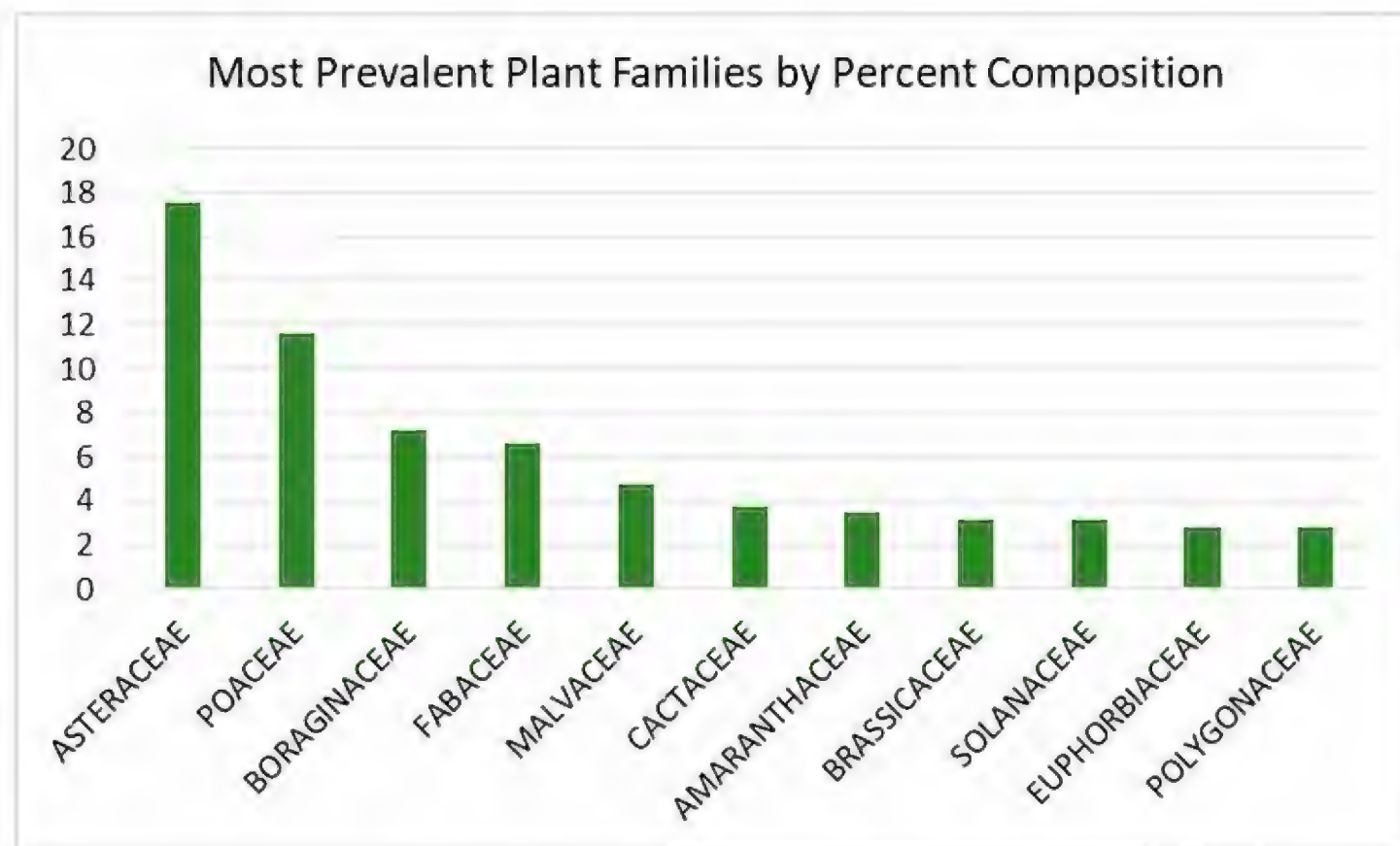


Figure 13. Most Common Plant Families in the White Tanks by Percent of Species.

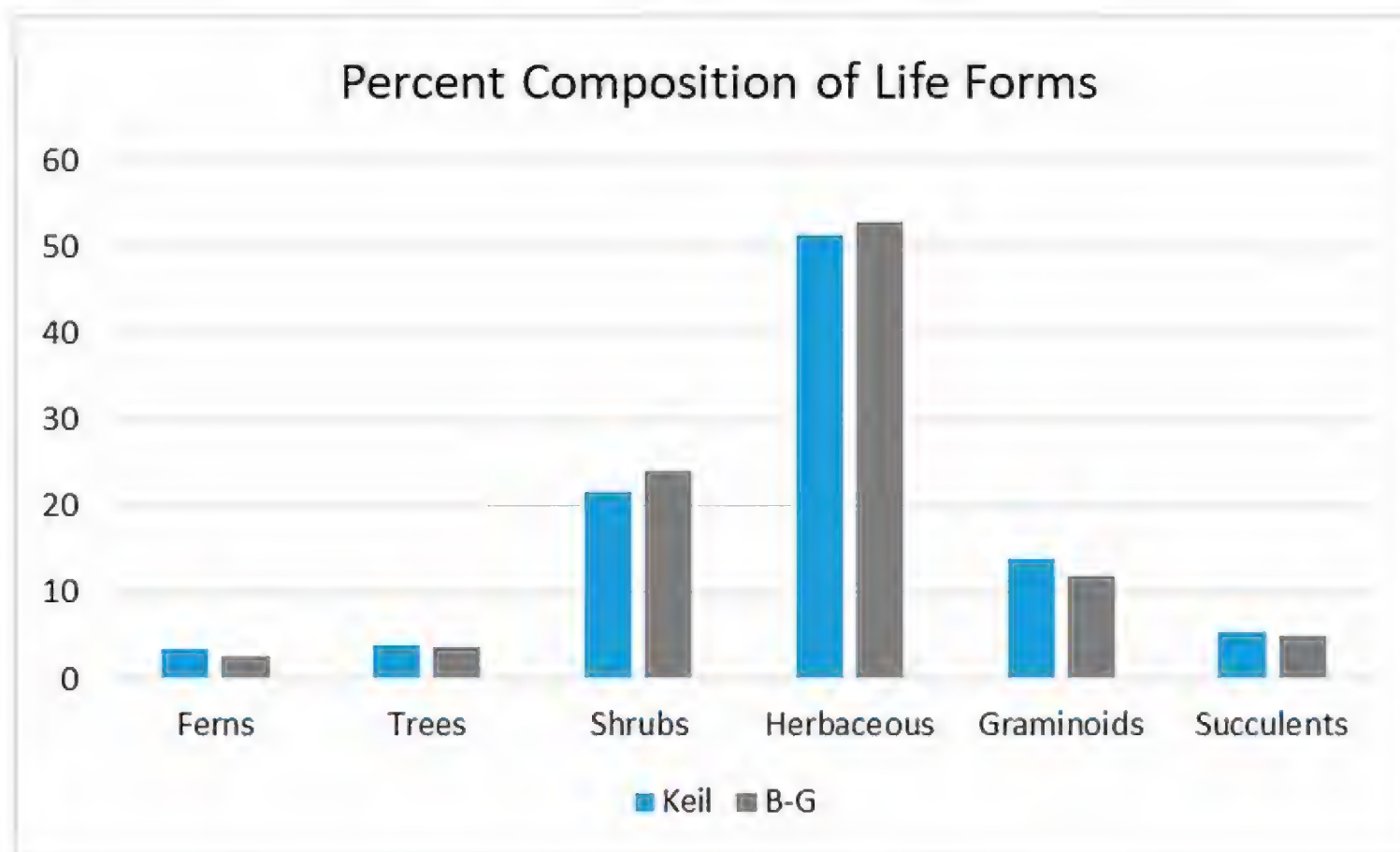


Figure 14. Plant composition of the White Tanks measured as life forms.

An interesting subset of the WTMRP flora are the 12 percent of plants whose reproductive phenology is brought on exclusively or nearly so by summer rain events (Table 2). The species listed in Table 2 meet two criteria. First, is that we collected them in the summer and fall seasons (August through November). Second, for each species, we analyzed a SEINet database of all collections made over time in the Phoenix Basin. We regard the months with the most collections made as a proxy for the peak flowering months for these species. Species with peak collection rates from August to November are listed in Table 2. Sixty percent of these species are annuals.

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Table 2. Plants predominantly responding to summer rain.

Family	Species	Dur	Family	Species	Dur
Aizoaceae	<i>Trianthema portulacastrum</i> *	A		<i>Abutilon palmeri</i>	P
Amaranthaceae	<i>Amaranthus albus</i>	A	Nyctaginaceae	<i>Allionia choisyi</i>	A
	<i>Amaranthus fimbriatus</i>	A		<i>Boerhavia intermedia</i>	A
	<i>Amaranthus obcordatus</i>	A	Poaceae	<i>Bouteloua aristidoides</i>	A
	<i>Amaranthus palmeri</i>	A		<i>Bouteloua barbata</i>	A
	<i>Chenopodium neomexicanum</i>	A		<i>Dasyochloa pulchella</i>	P
	<i>Tidestromia lanuginosa</i>	A		<i>Heteropogon contortus</i> *	P
Asteraceae	<i>Ambrosia monogyra</i>	P		<i>Muhlenbergia porteri</i>	P
	<i>Ericameria laricifolia</i>	P		<i>Panicum hirticaule</i>	A
	<i>Gutierrezia sarothrae</i> *	P		<i>Sporobolus airoides</i> *	P
	<i>Pectis papposa</i>	A		<i>Tridens muticus</i> var. <i>elongatus</i> *	P
	<i>Pectis rusbyi</i>	A		<i>Urochloa arizonica</i>	A
	<i>Stephanomeria tenuifolia</i>	P	Polygonaceae	<i>Eriogonum wrightii</i>	P
Convolvulaceae	<i>Cuscuta indecora</i> *	A	Solanaceae	<i>Datura discolor</i>	A
Cucurbitaceae	<i>Brandegea bigelovii</i>	A		<i>Lycium berlandieri</i> *	P
Euphorbiaceae	<i>Chamaesyce florida</i>	A	Talinaceae	<i>Talinum aurantiacum</i>	P
	<i>Chamaesyce revoluta</i>	A	Verbenaceae	<i>Aloysia wrightii</i>	P
	<i>Euphorbia abramsiana</i>	A	Zygophyllaceae	<i>Kallstroemia grandiflora</i>	A
Malvaceae	<i>Abutilon abutiloides</i> *	P		<i>Kallstroemia parviflora</i>	A
	<i>Abutilon incanum</i> *	P			

*Exhibit some bimodal response to rain, but mainly summer. Duration: A-Annual, P-Perennial.

NATIVE SPECIES NOT PREVIOUSLY VOUCHERED

There were 43 species encountered in this study not previously documented, 31 of which are native and listed in Table 3. Some of these plants may have always been in the park but were not vouchered before this study, and others are more recent introductions either by natural or human vectors. Three species on this list were probably introduced into an artificial pond, which has since dried out, and do not occur elsewhere in the park. These are *Nymphaea mexicana*, *Hydrocotyle verticillata*, and *Juncus torreyi*.

INTRODUCED SPECIES

Twenty-nine introduced plants were identified among our collections, including 12 that were not previously documented in the park. They include a few species that may have been present in the time of Keil's flora but were not found then. Most are species that are first known from the Phoenix Basin after 1970.

Table 4 lists the 29 introduced plants encountered in the present flora; the new arrivals are noted with an asterisk. Four introduced plants reported during the Keil flora were not found by the B-G flora. They are *Carthamus tinctorius*, *Ayenia insulicola*, *Eragrostis cilianensis* and *Polypogon viridis*. The last two are commonly encountered grasses, and possibly still reside in the park. The report of *Ayenia insulicola* is a misidentification of *Ayenia filiformis* (Sussman 2020). *Carthamus tinctorius* is rare in the Phoenix area and may only have been a transient resident.

Among the introduced plants that were not present in WTMRP in 1968 are four that are concerning due to their potential for negative ecological impacts. These are *Oncosiphon pilulifer* and *Brassica tournefortii*, listed as Class B noxious weeds by the Arizona Department of Agriculture (AZDA), and *Cenchrus ciliaris* and *Cenchrus setaceus*, listed as Class C noxious weeds by AZDA. (Arizona Department of Agriculture [AZDA] 2023).

Table 3. Newly Vouchered Native Plants of WTMRP.

Family	Species	Family	Species
Acanthaceae	<i>Justicia californica</i>	Caryophyllaceae	<i>Loeflingia squarrosa</i>
Aizoaceae	<i>Trianthema portulacastrum</i>	Convolvulaceae	<i>Cuscuta indecora</i>
Amaranthaceae	<i>Amaranthus albus</i>	Fabaceae	<i>Lupinus succulentus</i>
	<i>Blitum nuttallianum</i>	Gentianaceae	<i>Zeltnera calycosa</i>
	<i>Chenopodium neomexicanum</i>	Juncaceae	<i>Juncus torreyi</i> *
Araliaceae	<i>Hydrocotyle verticillata</i> *	Malvaceae	<i>Abutilon abutiloides</i>
Asteraceae	<i>Ambrosia monogyra</i>		<i>Ayenia compacta</i>
	<i>Geraea canescens</i>	Montiaceae	<i>Claytonia perfoliata</i>
	<i>Malacothrix coulteri</i>	Nyctaginaceae	<i>Abronia villosa</i>
	<i>Stephanomeria tenuifolia</i>	Nymphaeaceae	<i>Nymphaea mexicana</i> *
	<i>Verbesina encelioides</i>	Plantaginaceae	<i>Penstemon parryi</i>
Boraginaceae	<i>Eremocarya micrantha</i>	Polemoniaceae	<i>Gilia scopulorum</i>
	<i>Johnstonella angustifolia</i>	Polygonaceae	<i>Eriogonum pusillum</i>
	<i>Phacelia affinis</i>	Solanaceae	<i>Nicotiana clevelandii</i>
	<i>Phacelia tanacetifolia</i>	Talinaceae	<i>Talinum aurantiacum</i>
Cactaceae	<i>Cylindropuntia fulgida</i>		

*Plants collected in temporary, artificial pond.

Table 4. Introduced plants of WTMRP.

Family	Species	Family	Species
Amaranthaceae	<i>Chenopodiastrum murale</i>	Malvaceae	<i>Malva neglecta</i> *
	<i>Salsola tragus</i>		<i>Malva parviflora</i>
Asteraceae	<i>Centaurea melitensis</i> *	Poaceae	<i>Avena fatua</i>
	<i>Dimorphotheca sinuata</i> *		<i>Bromus rubens</i>
	<i>Oncosiphon pilulifer</i> *		<i>Cenchrus ciliaris</i> *
	<i>Sonchus asper</i>		<i>Cenchrus setaceus</i> *
	<i>Sonchus oleraceus</i>		<i>Cynodon dactylon</i>
Brassicaceae	<i>Brassica tournefortii</i> *		<i>Eragrostis lehmanniana</i> *
	<i>Matthiola parviflora</i> *		<i>Hordeum murinum</i>
	<i>Sisymbrium irio</i>		<i>Phalaris minor</i>
Caryophyllaceae	<i>Herniaria hirsuta</i> *		<i>Polypogon monspeliensis</i>
Cucurbitaceae	<i>Citrullus lanatus</i> *		<i>Schismus arabicus</i>
Fabaceae	<i>Melilotus indicus</i>		<i>Schismus barbatus</i>
Geraniaceae	<i>Erodium cicutarium</i>	Tamaricaceae	<i>Tamarix chinensis</i>
Linaceae	<i>Linum grandiflorum</i> *		

*New record for the B-G flora.

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Figure 15. Four species of concern in the White Tanks. (A) *Oncosiphon pilulifer*. Known in the region since 1997. Currently sparse but occurring everywhere in the park. (B) *Brassica tournefortii*. Known in the region since 1965. Distributed throughout the park, becoming dominant in the lower segments of the larger drainages. (C) *Cenchrus setaceus*. Known in the region since 1962. It occupies all the major drainages, becoming dominant in the wetter segments. Currently confined to the drainage channels. (D) *Cenchrus ciliaris*. Known in the region since 1972. It is ubiquitous in all major drainages and occasional along the park roads including OHV roads on the remote north and west sides of the mountains. It is becoming established outside drainages and roadsides.

CHANGES NOTED IN WETLAND PLANT ABUNDANCE

An early focus of field work for this study was to try to locate examples of perennial wetland plants vouchered in the Keil flora. This set of plants includes *Schoenoplectus americanus*, *Typha domingensis*, *Stemodia durantifolia*, (assigned wetland obligate [OBL] status by NWPL Plant Ratings [Lichvar 2013]), *Salix gooddingii*, *Salix exigua* and *Pluchea sericea* (assigned facultative wetland [FACW] status), and *Baccharis salicifolia* and *Populus fremontii* (assigned facultative [FAC] status). Even though not all these species are assigned OBL status, we assert that within the study area these species occur only in soils that are saturated nearly year-round and thus are all reliable indicators of the wettest locations in the park. Contrast that to the present when *Salix gooddingii* and *Pluchea sericea* are the only members of this group that remain in these locations.

Historically, springs are known in the park from four locations. These are documented in the Maricopa County Regional Park System Master Plan Update (MCRP 2014e).

Table 5. Known Springs in White Tank Mountain Regional Park

Location	Source
Section 23, T3N-R3W	Willow Spring
Section 23, T3N-R3W	Mesquite Spring
Section 26, T3N-R3W	Dripping Spring
Section 35, T3N-R3W	Unnamed spring (Here named Black Canyon Spring)

The locations of Willow and Mesquite springs are well known because the park trail system takes hikers to them. The exact location of Dripping Springs is not documented, but the segment of Dripping Springs Canyon where it likely occurs can be deduced from location information found on Keil's voucher labels and from images from Google Earth. Nothing

published about the unnamed spring was found, but the section and township information place it in the southernmost drainage within the park known as Black Canyon. A reconnoitering via Google Earth provided clues to possible locations. We explored the canyon and found that indeed a spring does occur there (referred to as Black Canyon Spring going forward). Figure 16 is a model of the mountain's eastern profile that depicts how the wetland-dependent perennials collected by both studies are distributed.

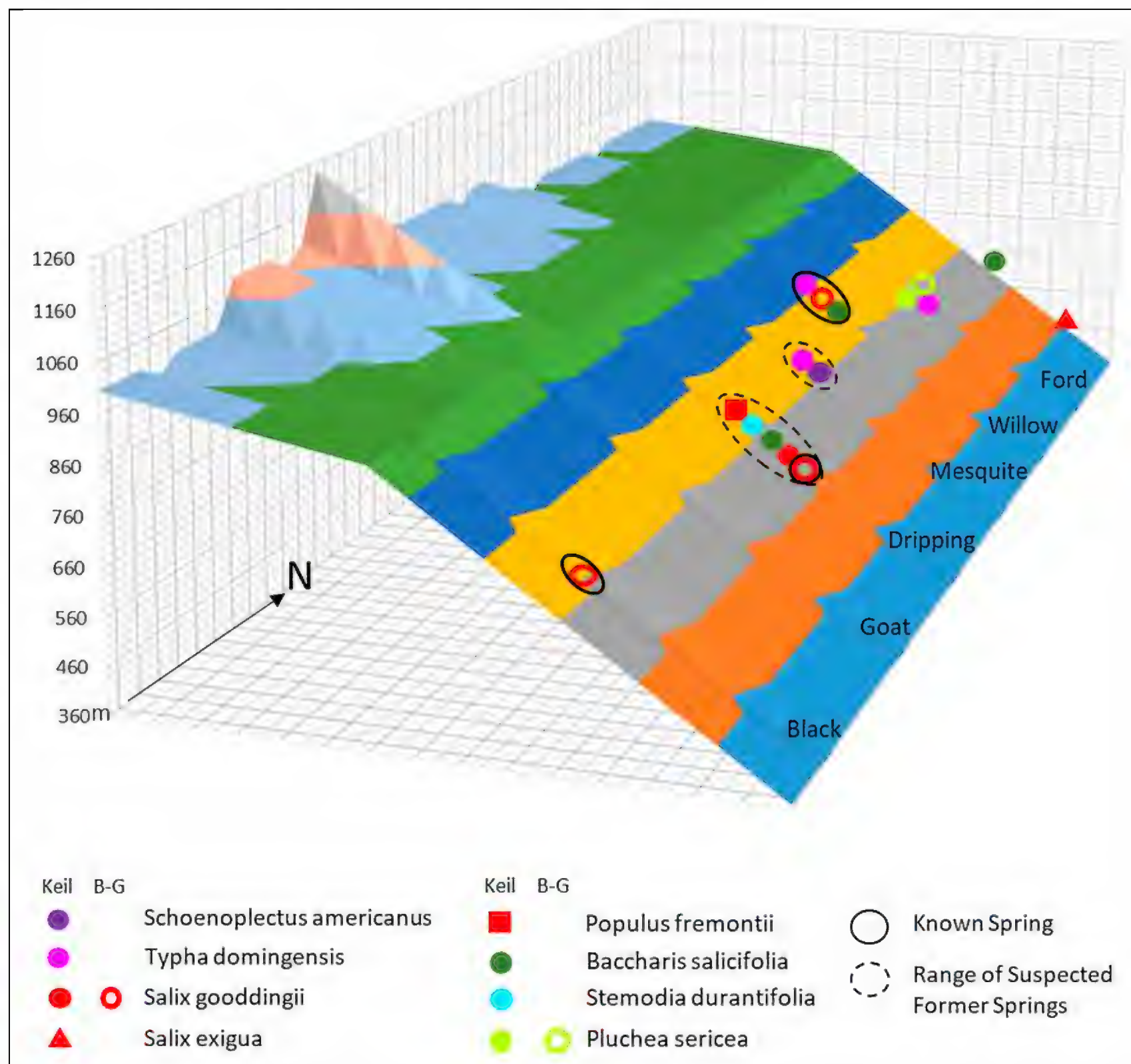


Figure 16. Approximate Locations of Wetland Perennial Vouchers. The north-south trend of the mountains is marked with the major east-west drainages. The voucher plot points are color-coded as indicated in the legend below the plot. Vouchers from the Keil flora are plotted with solid-colored markers and those of the B-G flora are plotted with hollow-bodied markers. Color bands indicate 100 m elevation increments.

It is clear that the variety of wetland obligate plants was richer in 1968 than today. Of the four locations, historically referred to as springs, none support any of the former cohort of wetland plants, except for *Salix gooddingii* and *Pluchea sericea*, and only Willow Spring and Black Canyon Spring feature surface water. Each of these locations occurs at an elevation band between ca. 600 m and 750 m (ca. 2000 ft and 2500 ft). All the major drainages level out within this elevation band and feature a stretch of mesic drainage for prolonged periods during wetter winters and springs. These may support wetland annuals such as *Erythranthe guttata* and

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Juncus bufonius, along with introduced plants with wetland affiliations including *Cynodon dactylon*, *Tamarix chinensis*, *Polypogon monspeliensis* and *Hordeum murinum*.

The few wetland habitats in the park are no longer hospitable to the cohort of plants they once supported. It is likely they have experienced a drying trend since the Keil flora.

CHANGES NOTED IN OTHER PLANT ABUNDANCE

Figure 17 is another attempt to visualize differences between 1968 and present. It is notable that Keil vouchered four *Castilleja lanata* specimens in the northern part of the park while the present study did not encounter any.

The region where they were collected is within the footprint of the 1993 Bug Fire, which burned on the northeast side of the park from the north side of Goat Camp Canyon to north of Ford Canyon. The burn zone now has many areas where legume trees and cacti are sparse, where *Encelia farinosa* dominates and, where in upper elevations and southern exposures, *Bromus rubens* is dense. If *Castilleja lanata* was still present prior to the burn, it is possible that the fire eliminated those plants and/or the hosts this population may have relied upon.

Keil vouchered a single specimen of *Calochortus kennedyi*. We don't know if he observed any others, but we have reasons to believe he did not. Keil collected most species (75%) multiple times over the course of his field work, as he did with *Castilleja lanata* above. It seems likely he would have collected a specimen from another location if he had found it. Since this single *Calochortus* voucher had fruit but no other flower parts, it seems likely that he would have made at least one other voucher if he had encountered another one with flowers. Finally, in his paper, Keil indicated that *C. kennedyi* is rare and from a single habitat type (Keil 1973). Therefore, we believe the voucher was likely made at the only location he encountered the plant.

The present study however, found the plant to be a common occurrence, particularly in the northern range of the park, within the burned region.

It is possible the 1993 Bug Fire may have eliminated competing plants, freeing up *C. kennedyi* to grow in the newly opened habitat. Alternatively, it may be that *C. kennedyi* was not all that rare, but was inconspicuous due to mule deer browsing which eliminated flowers prior to anthesis. Post-fire, the same landscape now more dominated by *Bromus rubens* may no longer be as heavily browsed (Heffelfinger et al. 2006), allowing more flowers to fully develop and the plant to propagate more successfully.

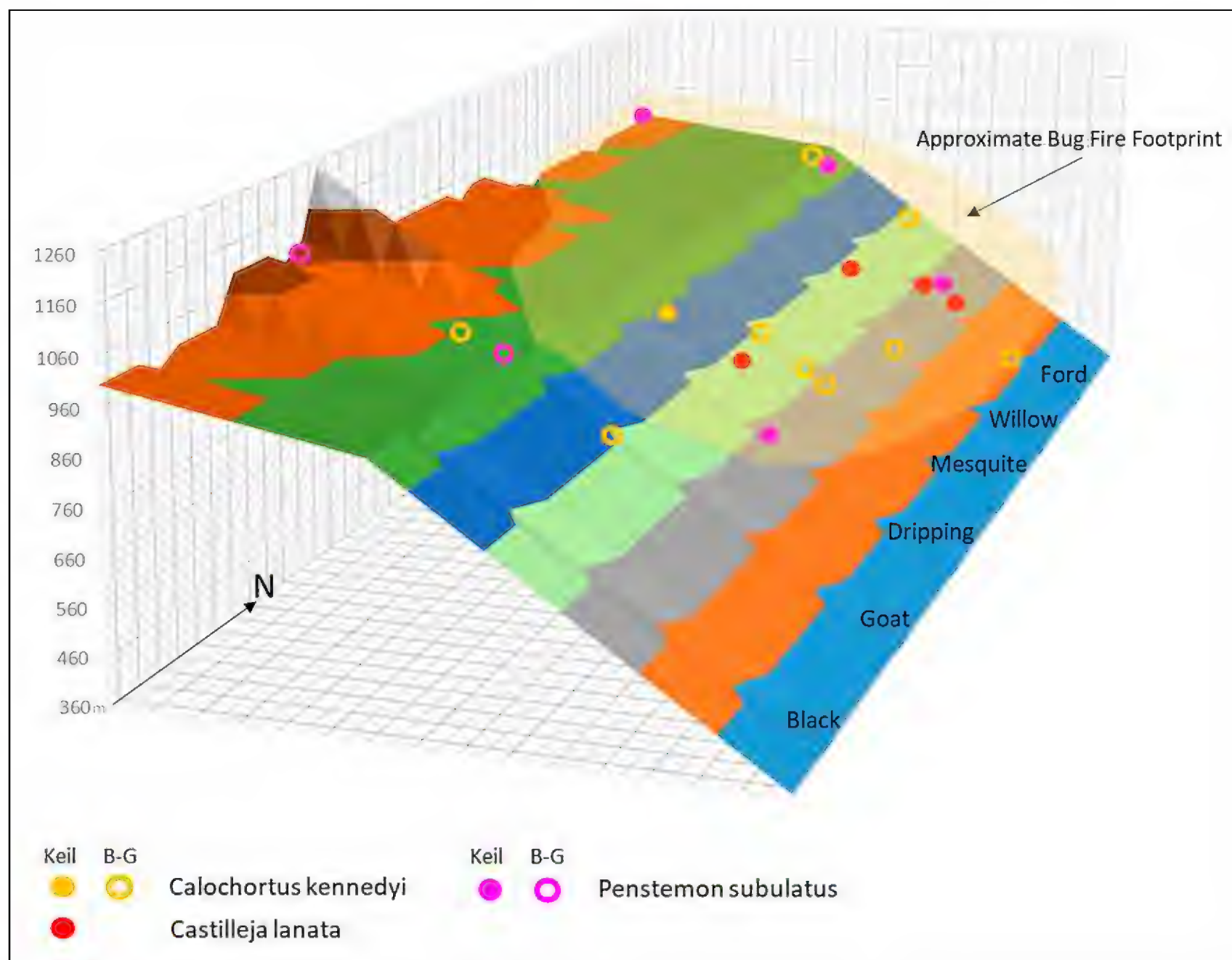


Figure 17. Plants with occurrence or range change potentially associated with the 1993 Bug Fire. The north-south trend of the mountains is marked with the major east-west drainages. The voucher plot points are color-coded as indicated in the legend below the plot. Vouchers from the Keil flora are plotted with solid-colored markers and those of the B-G flora are plotted with hollow-bodied markers. Color bands indicate 100 m elevation increments.

Penstemon subulatus is also absent from within the burn footprint. There were several collected in the earlier study throughout that area. The present study only encountered these plants to the south of the burn area and only at the highest elevations of the mountains. This may be additional evidence of changes due to the Bug Fire.

In the text of his thesis, Keil noted evidence of a fire pre-dating his study. On the north-facing slopes of ridgelines north of Ford Canyon and north of most of the Bug Fire footprint he observed charred remains of shrubs and trees (Keil 1970).

CHANGES IN CLIMATE AT WTMRP

The average annual temperature at WTMRP has increased in the decades since the Keil flora. Temperature data are available from several NOAA monitors situated in and around the city of Phoenix, but not from directly within the preserve. We use data from nearby Litchfield Park as a proxy for WTMRP and, where data points are missing from this record going back to 1960, points from nearby Youngtown and Wittman are used. Figure 19A is a plot of this data set with an added trend line showing a 0.774 °F (0.43 °C) per decade increase in average annual temperature. (NWS 2022a).

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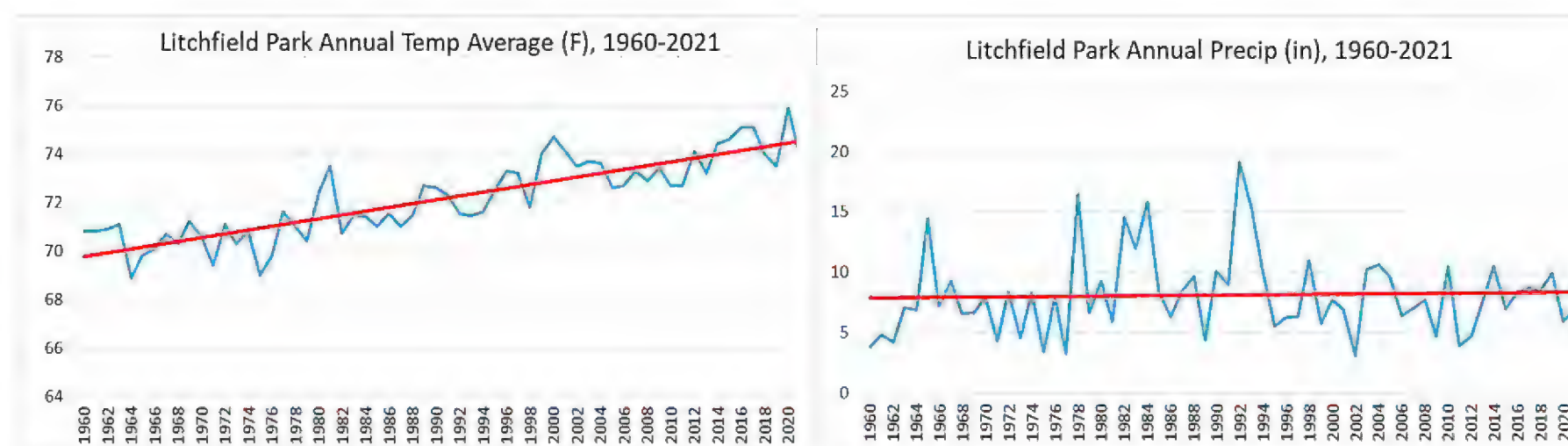


Figure 18. Climate trends measured near WTMRP. (A) Temperature trend, 1960-2021 (°F). (B) Annual precipitation, 1960-2021 (inches).

Additionally, the Phoenix area has experienced a doubling of the number of days per year with temperatures at or above 110°F (43 °C), from an average of 10 in the decade of the 1960s to an average of over 20 in the decade of the 2010s. It is projected to exceed 40 by the decade of the 2040s, with some years surpassing 60 (NWS 2021b).

Annual precipitation from 1960 to 2021 is shown in Figure 19B. Again, we refer to nearby Litchfield Park data as a WTMRP proxy (NWS 2022b). Even though precipitation can vary widely from year to year, there is no clear trend over time, with an average annual rainfall of 8 inches (203 mm). Despite there being no significant change to rainfall inputs, a state of drought has been in place in the region since 1994 (Arizona Climate Office 2022). This is illustrated by the Standardized Precipitation-Evapotranspiration Index (SPEI) (Figure 19) for the region. SPEI is able to measure drought conditions caused by persistent heat-driven evapotranspiration in the absence of rain deficits (Vincente-Serrano et al. 2010).

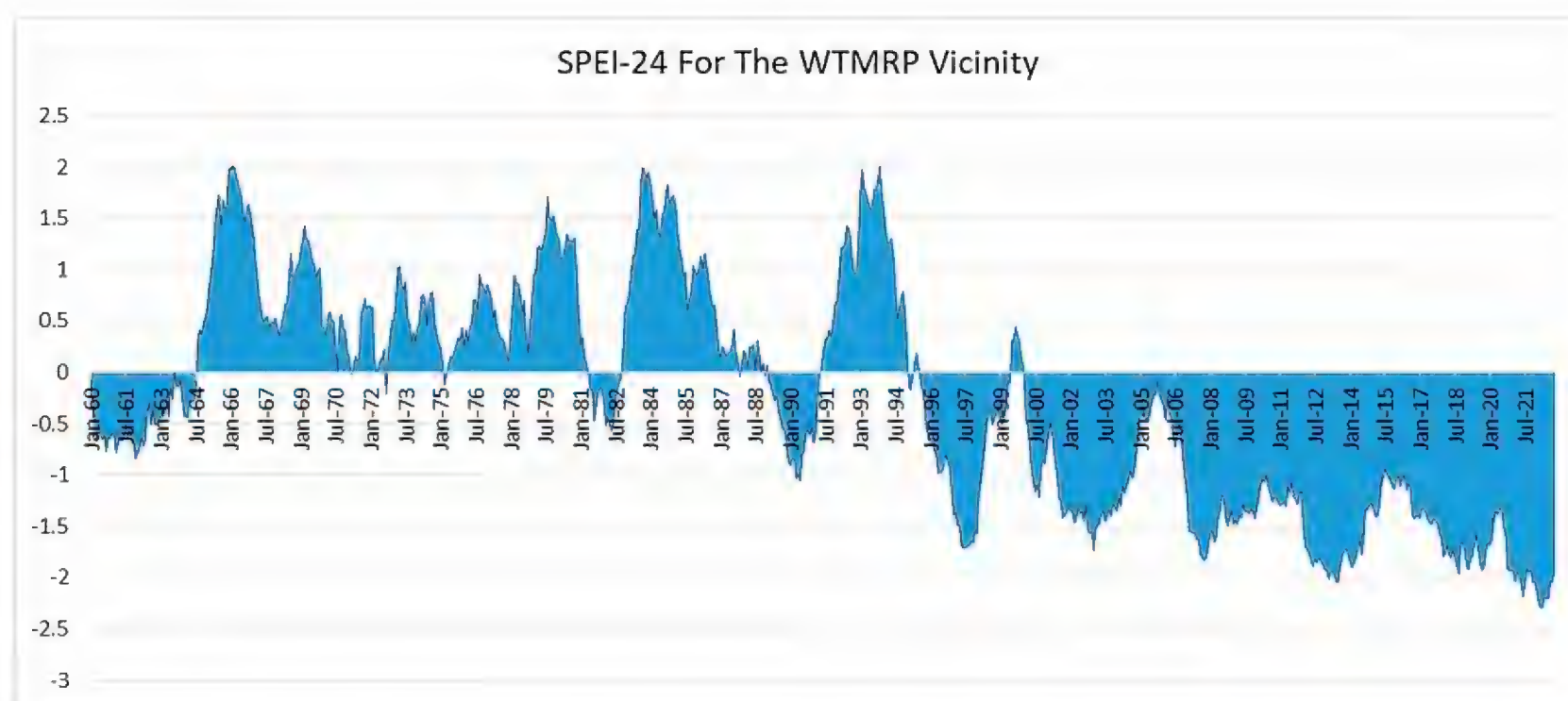


Figure 19. Twenty-four-month intervals of the Standardized Precipitation-Evapotranspiration Index (SPEI), a measure of moisture surplus (positive) or deficit (negative) for the vicinity of WTMRP from 1960–2021. Each vertical bar indicates the departure from the average condition over the period in standard deviations. Conditions of drought emerged in 1995–1996 that persist and have intensified to the present. Data source: SPEI Global Drought Monitor (spei.csic.es), Accessed 11/2022.

CHANGES IN SURROUNDING AQUIFER

The hydrology of WTMP's few springs and other mesic habitats may be affected by the change in the level of the surrounding valley aquifers. According to Hipke et al. (2014), groundwater pumping accelerated in the 1950s to support agriculture and by 1983, the Agua Fria water table had dropped 61–76 m (200–250 ft) near the eastern flanks of the mountains. This depletion has been accompanied by up to 5.5 m (18 ft) of subsidence in some areas. Groundwater use projections out to 2025 forecast another 30–46 m (100–150 ft) of decline in the aquifer.

This is a striking loss and prompts us to speculate what coupling, if any, there may be between the depletion of the Aqua Fria aquifer and the amount and duration of surface water in the White Tank Mountains. It is a question beyond our expertise to answer. This study does, however, document the loss of a cohort of wetland obligate species, which is consistent with such coupling (Figure 16).

Interestingly, a 1973 voucher of *Populus fremontii* (Figure 19), a tree dependent on a proximate water table, includes this description: “One large tree, partially fallen, but still alive.” This field note may have captured the early effects of a declining surrounding aquifer on the mountains in real time. While there is no evidence of living *P. fremontii* trees within the preserve today, we encountered interesting remains of a tree in a location that roughly correlate with Keil’s location description. Testing is in progress to determine if this is a *P. fremontii* remnant.



A



B

Figure 19. (A) 1973 voucher of *Populus fremontii* from Dripping Springs Canyon. (B) Possible remains of this tree in Dripping Springs Canyon, 2020.

MISSING SPECIES

Among the species in the Keil flora checklist, 64 of them (ca. 18%) were not encountered by the B-G flora. These are listed in Table 6. Two of the species, *Typha domingensis* and

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Schoenoplectus americanus, were vouchered from an artificial pond, which is now dry. We include them in the missing species list since the Keil flora found them growing naturally, while we found them in an artificial habitat.

Table 6. Species previously collected at WTMRP not encountered in the B-G study.

Amaranthaceae <i>Amaranthus crassipes</i> <i>Chenopodium leptophyllum</i>	Convolvulaceae <i>Cuscuta tuberculata</i> <i>Cuscuta umbellata</i>	Poaceae <i>Aristida ternipes</i> <i>Bouteloua trifida</i> <i>Chloris virgata</i> <i>Digitaria californica</i> <i>Diplachne fusca</i> <i>Eragrostis cilianensis</i> <i>Muhlenbergia rigens</i> <i>Phalaris caroliniana</i> <i>Polypogon viridis</i> <i>Setaria leucopila</i> <i>Sporobolus contractus</i>
Anacardiaceae <i>Rhus aromatica</i>	Cucurbitaceae <i>Cucurbita digitata</i>	Polygalaceae <i>Polygala macradenia</i>
Apiaceae <i>Yabea microcarpa</i>	Cyperaceae <i>Schoenoplectus americanus</i> *	Primulaceae <i>Androsace occidentalis</i>
Asparagaceae <i>Hesperocallis undulata</i>	Ephedraceae <i>Ephedra aspera</i>	Pteridaceae <i>Myriopteris wrightii</i> <i>Notholaena californica</i>
Asteraceae <i>Baccharis salicifolia</i> <i>Calycoseris wrightii</i> <i>Carthamus tinctorius</i> <i>Gaillardia arizonica</i> <i>Helianthus annuus</i> <i>Isocoma acradenia</i> <i>Malacothrix sonora</i> <i>Malacothrix stebbinsii</i> <i>Pseudognaphalium canescens</i>	Euphorbiaceae <i>Bernardia incana</i> <i>Chamaesyce capitellata</i> <i>Chamaesyce setiloba</i>	Ranunculaceae <i>Myosurus cupulatus</i>
Boraginaceae <i>Cryptantha decipiens</i> <i>Cryptantha juniperensis</i> <i>Nama hispida</i> <i>Pectocarya setosa</i>	Lamiaceae <i>Hedeoma nana</i>	Resedaceae <i>Oligomeris linifolia</i>
Brassicaceae <i>Dimorphocarpa wislizeni</i> <i>Lepidium virginicum</i>	Loasaceae <i>Mentzelia jonesii</i>	Salicaceae <i>Populus fremontii</i> <i>Salix exigua</i>
Cactaceae <i>Cylindropuntia arbuscula</i>	Malvaceae <i>Abutilon parvulum</i>	Solanaceae <i>Solanum elaeagnifolium</i>
Campanulaceae <i>Triodanis perfoliata</i>	Martyniaceae <i>Proboscidea parviflora</i>	Typhaceae <i>Typha Domingensis</i> *
Caryophyllaceae <i>Stellaria nitens</i>	Molluginaceae <i>Mollugo cerviana</i>	Zygophyllaceae <i>Kallstroemia californica</i>
	Nyctaginaceae <i>Boerhavia wrightii</i>	
	Onagraceae <i>Eremothera chamaenerioides</i>	
	Orobanchaceae <i>Castilleja lanata</i>	
	Plantaginaceae <i>Maurandya antirrhiniflora</i> <i>Stemodia durantifolia</i>	

* Indicates that the species was only vouchered by the B-G flora at an artificial pond that is no longer present.

Those familiar with the flora of the Phoenix Basin will recognize some of the species in Table 6 as being common in the region. For example, *Nama hispida*, *Helianthus annuus*, and *Oligomeris linifolia* have been vouchered at numerous locations in recent decades. It is also

possible we have overlooked plants such as *Cryptantha* spp. and some Pteridaceae, which include species that are difficult to distinguish in the field. It is likely that some of these will be found in WTMRP in the future.

Conversely, there are species from Table 6 that are rare or even unknown from any other locales in the region. For example, *Castilleja lanata*, collected from what is now the Bug Fire burn footprint and known historically only from one other place in the Phoenix Basin may no longer be present. Species that might be at the extreme of their range in WTMRP such as *Triodanis perfoliata* and *Rhus aromatica* may no longer be present. Considering the apparent reduction of wetland habitats in WTMRP, *Populus fremontii* and *Salix exigua* that depend on such habitats are unlikely to be found.

COMPARISON WITH OTHER PRESERVES

It is reasonable to assume that the floras of other mountain preserves in the Phoenix Basin would have most species in common. We considered five of these: San Tan Mountain Regional Park, Estrella Mountain Regional Park, South Mountain Preserve, McDowell Sonoran Preserve, and White Tank Mountain Regional Park. Voucher records from SEINet were used to generate checklists which were then compared. The shaded (gray) regions in Figure 20 show the SEINet search polygons used to extract records for each park or preserve region.



Figure 20. Database Search Polygons (gray shading) superimposed on a map encompassing the area. (A) White Tank Mountain Regional Park (B) McDowell Sonoran Preserve (C) Estrella Mountain Regional Park (D) South Mountain Preserve (E) San Tan Mountain Regional Park. Imagery from SEINet.

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Species common to two or more checklists were labeled “common,” while species restricted to just one checklist were labeled “unique.” The results (Figure 21, enclosed in the rectangle) show that from 11 to 19 percent of each flora is restricted to that mountain preserve; with 15 percent of WTMRP’s flora in that “unique” category.

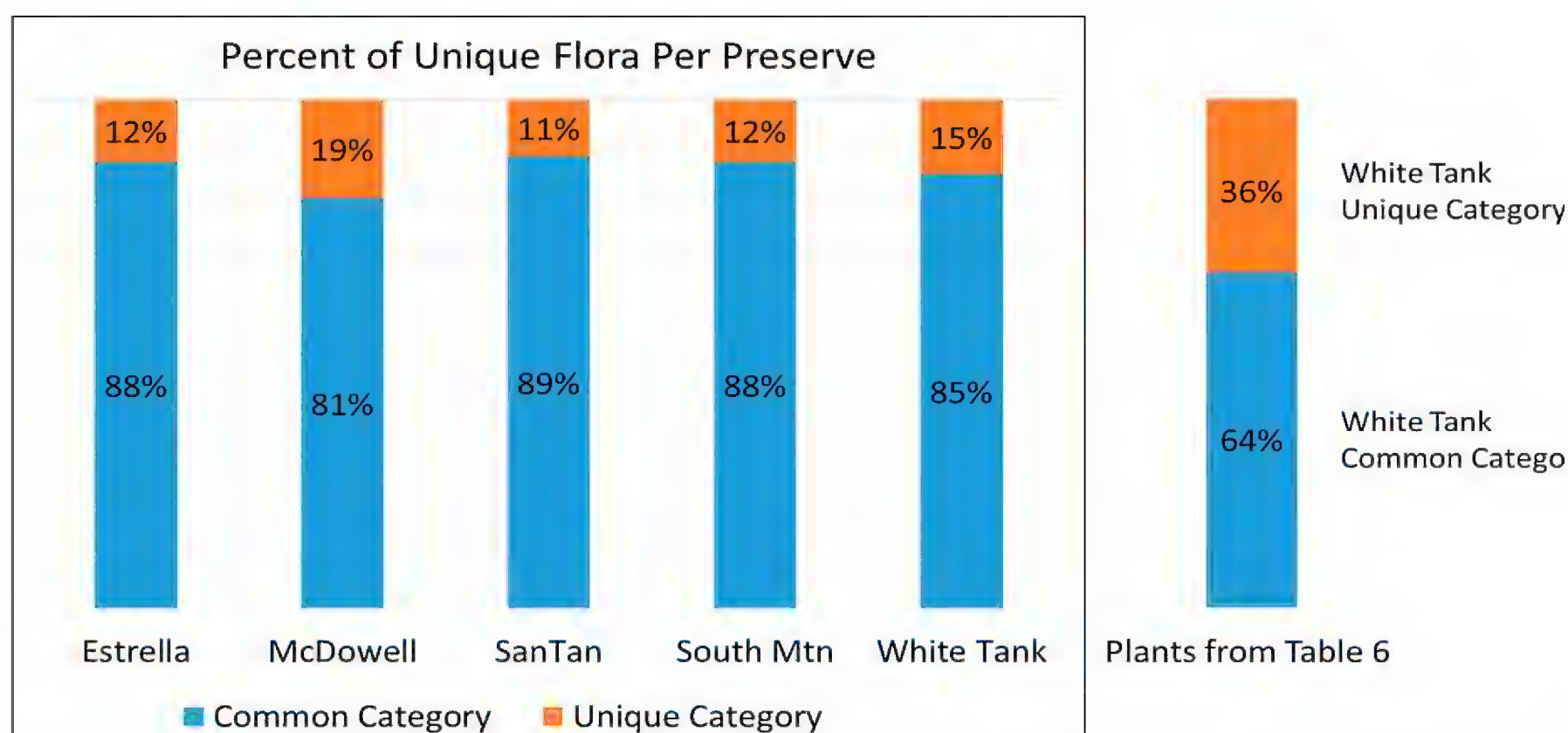


Figure 21. Composition of the flora of five mountain preserves in the Phoenix area expressed as the percent of species common to more than one preserve and the percent of species restricted to just one. The additional bar to the right shows the composition of plants from Table 6 expressed as the percent of species in White Tank’s “common” and “unique” categories.

The far-right portion of the bar graph in Figure 21 puts the plants from Table 6 in this context. Since Table 6 lists species that are potentially lost from the WTMRP flora, it is interesting to note that they are not proportionally distributed among the two categories of White Tank plants but are skewed toward the “unique” category.

ANNOTATED CHECKLIST

The checklist presented here is the superset of plants in both the Keil and B-G floras. Species are arranged alphabetically, first by family, and then by scientific name. The plant name is followed by an indication of which flora study vouchered the plant (Keil or B-G, or both) and a list of at least one voucher per species. If a species was found only by Keil, his voucher is listed. Indication of non-native status is made with an asterisk (*) appended to the plant name.

Vouchers are cited by the collector's initials appended with the collection number. Table 7 is a list of collectors and their initials. Some voucher citations include an explicit herbarium identifier in square brackets, following Index Herbariorum <https://sweetgum.nybg.org/science/ih>. See also Table 8.

For example, the voucher citation DA17400A [BRY], cites a collection by Duane Atwood, with collection number 17400A, which is housed at the Brigham Young University, S. L. Welsh Herbarium.

The vouchers of collectors CB and DG (see Table 7) are all housed in the Herbarium of Desert Botanical Garden (DES). Unless otherwise noted, the vouchers of collector DK are housed in the Herbarium at Arizona State University (ASU). The vouchers of all other collections are cited with an explicit herbarium identifier (see Table 8).

Table 7. Collectors and Initials

Initials	Collector
CB	Cass Blodgett
DG	Dawn Goldman
DK	David Keil
EL	Elinor Lehto
CS	Cindy Smith
200PS-	CAPLTER Program
WH	Wendy C. Hodgson
RP	Raul Puente
ZB	Zachery Berry
DS	David Sussman
DA	Duane Atwood
CM	C. W. McClellan
MM	Malcolm G. McLeod

Table 8. Herbarium Names and Abbreviations

Abrev	Herbarium
DES	Desert Botanical Garden Herbarium
ASU	Arizona State University Vascular Plant Herbarium
UNM	University of New Mexico Herbarium
BRY	Brigham Young University, S. L. Welsh Herbarium
SEINet	General Research Observations*

*Photo-only vouchers entered into the SEINet database <https://swbiodiversity.org/seinet>.

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	Keil	B-G
ACANTHACEAE		
<i>Carlowrightia arizonica</i> A. Gray	•	• DG847, CB675, DG680
<i>Justicia californica</i> (Benth.) D. Gibson		• 200PS-J111-30 [ASU]
AIZOACEAE		
<i>Trianthema portulacastrum</i> L.		• CB1185
AMARANTHACEAE		
<i>Amaranthus albus</i> L.		• CB1188
<i>Amaranthus crassipes</i> Schlecht.	•	DK5779
<i>Amaranthus fimbriatus</i> (Torr.) Benth. ex S. Wats.	•	• CB1075, DG828, CB1223
<i>Amaranthus obcordatus</i> (A. Gray) Standl.	•	• CB1184
<i>Amaranthus palmeri</i> S. Watson	•	• CB1087
<i>Atriplex canescens</i> (Pursh) Nutt.	•	• CB1129
<i>Atriplex elegans</i> (Moq.) D. Dietr.	•	• CB726
<i>Blitum nuttallianum</i> Schult.		• CB813
<i>Chenopodiastrium murale</i> (L.) S. Fuentes-B, Uotila & Borsch*	•	• CB893, DG729, CB795
<i>Chenopodium leptophyllum</i> (Moq.) Nutt. ex S. Wats.	•	DK4779
<i>Chenopodium neomexicanum</i> Standl.		• DG832
<i>Salsola tragus</i> L.*	•	• DG689
<i>Tidestromia lanuginosa</i> (Nutt.) Standl.	•	• CB1074, CB769, DG883
ANACARDIACEAE		
<i>Rhus aromatica</i> Aiton	•	DK11208
APIACEAE		
<i>Bowlesia incana</i> Ruiz & Pav.	•	• CB871, CB700, CB548
<i>Daucus pusillus</i> Michx.	•	• CB649, DG785
<i>Yabea microcarpa</i> (Hook. & Arn.) K.-Pol.	•	DK4184, DK3139
APOCYNACEAE		
<i>Funastrum heterophyllum</i> (Engelm. ex Torr.) Standl.	•	• CB1011, CB703
<i>Matelea parvifolia</i> (Torr.) Woods.	•	• DG805, CB580
<i>Metastelma arizonicum</i> A. Gray	•	• CB1434
ARALIACEAE		
<i>Hydrocotyle verticillata</i> Thunb.		• CB729
ARISTOLOCHIACEAE		
<i>Aristolochia watsonii</i> Woot. & Standl.	•	DK5787
ASPARAGACEAE		
<i>Agave simplex</i> (Gentry) Salywon & W.C. Hodgson	•	• DG856, DG858A, CB1170, CB1169
<i>Dichelostemma capitatum</i> (Benth.) Alph. Wood	•	• CB826, CB865, CB910
<i>Hesperocallis undulata</i> A. Gray	•	EL17625 [ASU], CM274, DA17400A [BRY]
ASTERACEAE		
<i>Acamptopappus sphaerocephalus</i> (Harv. & A. Gray) A. Gray	•	• CB968
<i>Acourtia wrightii</i> (A. Gray) Reveal & R. M. King	•	• CB1005, CB620
<i>Adenophyllum porophylloides</i> (A. Gray) Strother	•	• DG685, CB1408, DG818
<i>Ambrosia ambrosioides</i> (Cav.) W.W. Payne	•	• DG796, CB664, DG666
<i>Ambrosia confertiflora</i> DC.	•	• CB1469 [SEINet Obser.]
<i>Ambrosia deltoidea</i> (Torr.) W.W. Payne	•	• CB421, DG841, CB563
<i>Ambrosia dumosa</i> (A. Gray) W.W. Payne	•	• CB465, CB672
<i>Ambrosia monogyra</i> (Torr. & A. Gray) Strother & B.G. Baldwin		• CB1465
<i>Ambrosia salsola</i> (Torr. & A. Gray) Strother & B.G. Baldwin	•	• CB1030, CB535, DG773
<i>Artemisia ludoviciana</i> Nutt.	•	• CB1138, CB631, CB1105
<i>Baccharis salicifolia</i> (Ruiz & Pav.) Pers.	•	DK5983, DK4737, DK6232
<i>Baccharis sarothroides</i> A. Gray	•	• CB1086, CB1155
<i>Baccharis sergiloides</i> A. Gray	•	• CB1440
<i>Bahiopsis parishii</i> (Greene) E.E. Schilling & Panero	•	• DG872, CB686, CB565
<i>Baileya multiradiata</i> Harv. & A. Gray	•	• CB1402
<i>Baileya pleniradiata</i> Harv. & A. Gray	•	EL17634 [ASU]
<i>Bebbia juncea</i> (Benth.) Greene	•	• DG845, CB696, CB1410
<i>Brickellia atractylodes</i> A. Gray	•	• CB1141
<i>Brickellia coulteri</i> A. Gray	•	• CB1140, CB559, DG653

<i>Calycoseris wrightii</i> A. Gray	•	DK3205
<i>Carthamus tinctorius</i> L.*	•	EL17635 [ASU]
<i>Centaurea melitensis</i> L.*	•	CB1350
<i>Chaenactis carphoclinia</i> A. Gray	•	CB499, CB935
<i>Chaenactis stevioides</i> Hook. & Arn.	•	CB480, CB432, DG745
<i>Cirsium neomexicanum</i> A. Gray	•	CB1313, DG808, CB1409
<i>Conyza canadensis</i> (L.) Cronquist	•	200PS-K121-26 [ASU]
<i>Dimorphotheca sinuata</i> Dc.*	•	CB828
<i>Encelia farinosa</i> A. Gray ex Torr.	•	CB533, CB458, CB483
<i>Ericameria laricifolia</i> (A. Gray) Shinnars	•	CB1347, CB1237, CB1230
<i>Erigeron divergens</i> Torr. & A. Gray	•	CB707
<i>Erigeron lobatus</i> A. Nels.	•	CB588, CB1264, DG789
<i>Erigeron oxyphyllus</i> Greene	•	CB630, CB1235
<i>Eriophyllum lanosum</i> (A. Gray) A. Gray	•	CB847, CB471, DG754
<i>Gaillardia arizonica</i> A. Gray	•	DK6280
<i>Geraea canescens</i> Torr. & A. Gray	•	CB1462
<i>Gutierrezia sarothrae</i> (Pursh) Britton & Rusby	•	CB765, CB583
<i>Helianthus annuus</i> L.	•	DK1973-12-21
<i>Isocoma acradenia</i> (Greene) Greene	•	CB1473
<i>Lasthenia californica</i> DC. ex Lindl.	•	CB928
<i>Logfia arizonica</i> (A. Gray) J. Holub	•	CB857, CB557, CB1319
<i>Logfia filaginoides</i> (Hook. & Arn.) Morefield	•	CB1275, DG817, CB1006
<i>Malacothrix coulteri</i> Harv. & A. Gray	•	CB1393
<i>Malacothrix glabrata</i> (A. Gray ex D.C. Eaton) A. Gray	•	DG787, DG747
<i>Malacothrix sonora</i> W.S. Davis & Raven	•	MM6275 [ASU]
<i>Malacothrix stebbinsii</i> W.S. Davis & Raven	•	DK6306
<i>Melampodium leucanthum</i> Torr. & A. Gray	•	DG820
<i>Monoptilon bellioides</i> (A. Gray) Hall	•	CB456, CB1401, DG622
<i>Oncosiphon pilulifer</i> (L. f.) Kallersjo*	•	CB1310, CB494, DG763
<i>Pectis papposa</i> Harv. & A. Gray	•	CB1060, DG861, CB1207
<i>Pectis rusbyi</i> Greene ex A. Gray	•	DG701, DG825
<i>Perityle emoryi</i> Torr.	•	CB545, CB439, DG743
<i>Pluchea sericea</i> (Nutt.) Coville	•	CB731, CB1435, CB697
<i>Porophyllum gracile</i> Benth.	•	CB983, CB735, CB1315
<i>Pseudognaphalium canescens</i> (DC.) Anderb.	•	DK6309
<i>Psilostrophe cooperi</i> (A. Gray) Greene	•	CB1403, CB1411, CB997
<i>Rafinesquia californica</i> Nutt.	•	CB1007, CB1042, DG720
<i>Rafinesquia neomexicana</i> A. Gray	•	DG771, CB951, CB862
<i>Senecio lemmonii</i> A. Gray	•	DG758, CB598, CB1369
<i>Sonchus asper</i> (L.) Hill*	•	CB1390, CB1265
<i>Sonchus oleraceus</i> L.*	•	CB1158, DG786, CB840
<i>Stephanomeria pauciflora</i> (Torr.) A. Nels.	•	DG634, CB638, DG667
<i>Stephanomeria tenuifolia</i> (Raf.) Hall	•	CB1078, DG887
<i>Stylocline micropoides</i> A. Gray	•	CB1365, CB994, DG819
<i>Trichoptilium incisum</i> (A. Gray) A. Gray	•	CB435
<i>Trixis californica</i> Kellogg	•	CB475, DG846, DG657
<i>Uropappus lindleyi</i> (DC.) Nutt.	•	CB902, CB936, CB993
<i>Verbesina encelioides</i> (Cav.) Benth. & Hook. f. ex A. Gray	•	DG894, CS7 [DES], CB1224
<i>Xanthisma spinulosum</i> (Pursh) D.R. Morgan & R.L. Hartman	•	CB1379, CB1000, CB1004
<i>Xanthisma spinulosum</i> var. <i>gooddingii</i> (A. Nelson) D.R. Morgan & R.L. Hartman	•	CB1103
BORAGINACEAE		
<i>Amsinckia intermedia</i> Fisch. & C.A. Mey.	•	DG895, CB880, CB780
<i>Amsinckia tessellata</i> A. Gray	•	DG704
<i>Cryptantha barbigera</i> (A. Gray) Greene	•	DG676, CB940, CB895
<i>Cryptantha decipiens</i> (M.E. Jones) Heller	•	DK4742, DK6224-a
<i>Cryptantha juniperensis</i> R.B. Kelley & M.G. Simpson	•	DK6212
<i>Cryptantha maritima</i> (Greene) Greene	•	CB1253, DG900, CB426
<i>Cryptantha pterocarya</i> (Torr.) Greene	•	CB1252, CB972, CB1134

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<i>Emmenanthe penduliflora</i> Benth.	•	•	CB1316, CB1156, DG794
<i>Eremocarya micrantha</i> (Torr.) Greene		•	CB1467
<i>Eucrypta chrysanthemifolia</i> (Benth.) Greene	•	•	CB777, DG711, DG628
<i>Eucrypta chrysanthemifolia</i> var. <i>bipinnatifida</i> (Torr.) Constance	•	•	CB890, CB906
<i>Eucrypta micrantha</i> (Torr.) Heller	•	•	CB837
<i>Nama hispida</i> A. Gray	•		DK6295
<i>Harpagonella palmeri</i> A. Gray	•	•	CB1360, CB992, CB1241
<i>Johnstonella angustifolia</i> (Torr.) Hasenstab & M.G. Simpson	•	•	DG690
<i>Pectocarya heterocarpa</i> (I.M. Johnston) I.M. Johnston	•	•	CB718
<i>Pectocarya platycarpa</i> (Munz & I. M. Johnst.) Munz & I. M. Johnst.	•	•	DG623, DG753, CB816
<i>Pectocarya recurvata</i> I.M. Johnston	•	•	CB425, CB791, CB449
<i>Pectocarya setosa</i> A. Gray	•		DK6241, DK4805
<i>Phacelia affinis</i> A. Gray		•	DG649
<i>Phacelia crenulata</i> Torr. ex S. Watson	•	•	CB861, CB445, DG631
<i>Phacelia distans</i> Benth.	•	•	CB794, DG850, DG742
<i>Phacelia tanacetifolia</i> Benth.		•	CB877
<i>Pholistoma auritum</i> (Lindl.) Lilja	•	•	CB822, DG838, CB797
<i>Plagiobothrys arizonicus</i> (A. Gray) Greene ex A. Gray	•	•	CB1256, CB937, CB852
<i>Plagiobothrys jonesii</i> A. Gray	•	•	CB442, CB479
BRASSICACEAE			
<i>Boechera perennans</i> (S. Watson) W. A. Weber	•	•	CB914, CB1104
<i>Brassica tournefortii</i> Gouan*		•	DG705, CB431, CB876
<i>Caulanthus lasiophyllus</i> (Hook. & Arn.) Payson	•	•	DG804, CB453, CB1251
<i>Descurainia pinnata</i> (Walter) Britton	•	•	DG713, CB454, CB829
<i>Dimorphocarpa wislizeni</i> (Engelm.) Rollins	•		EL17637 [ASU]
<i>Draba cuneifolia</i> Nutt. ex Torr. & A. Gray	•	•	CB1240, CS2 [DES]
<i>Lepidium lasiocarpum</i> Nutt.	•	•	CB1092, CB887, CB779
<i>Lepidium lasiocarpum</i> var. <i>lasiocarpum</i> Nutt. ex Torr. & A. Gray	•	•	CB702, DG706, DG736
<i>Lepidium virginicum</i> L.	•		DK1968-03-30, DK6207
<i>Matthiola parviflora</i> (Schousb.) W.T. Aiton*		•	CB827
<i>Physaria tenella</i> (A. Nelson) O'Kane & Al-Shehbaz	•	•	DG750, CB809, CB843
<i>Sisymbrium irio</i> L.*	•	•	CB814, CB651, CB716
<i>Thysanocarpus curvipes</i> Hook.	•	•	DG708, CB870, CB498
BURSERACEAE			
<i>Bursera microphylla</i> A. Gray	•	•	CB1431, DG695
CACTACEAE			
<i>Carnegiea gigantea</i> (Engelm.) Britton & Rose	•	•	CB1159, CB1162, CB1164
<i>Cylindropuntia acanthocarpa</i> (Engelm. & Bigelow) F.M. Knuth	•	•	CB1107, DG855, CB1058
<i>Cylindropuntia arbuscula</i> (Engelm.) Knuth	•		DK4096, MM143 [ASU], EL4219 [ASU]
<i>Cylindropuntia bigelovii</i> (Engelm.) Knuth	•	•	CB1163, CB750, DG855
<i>Cylindropuntia fulgida</i> (Engelm.) Knuth		•	CB1038
<i>Cylindropuntia leptocaulis</i> (DC.) Knuth	•	•	CB950
<i>Echinocereus engelmannii</i> (Parry ex Engelm.) Lem.	•	•	CB1395, CB1147
<i>Echinocereus engelmannii</i> var. <i>engelmannii</i>	•	•	WH30709 [DES], WH30709 [DES]
<i>Ferocactus cylindraceus</i> (Engelm.) Orcutt	•	•	CB1160, CB752, CB1090
<i>Mammillaria grahamii</i> Engelm.	•	•	CB1246, WH30694 [DES], CB751
<i>Opuntia chlorotica</i> Engelm. & Bigelow	•	•	CB1084, CB1171
<i>Opuntia engelmannii</i> var. <i>engelmannii</i> Salm-Dyck ex Engelm.	•	•	RP5282 [DES]
<i>Opuntia engelmannii</i> var. <i>flavispina</i> (L. Benson) Parfitt & Pinkava	•	•	WH31136 [DES], CB1044
<i>Peniocereus greggii</i> (Engelm.) Britt. & Rose	•	•	CB760 [SEINet Obser.]
CAMPANULACEAE			
<i>Triodanis perfoliata</i> (L.) Nieuwl.	•		DK6305
CANNABACEAE			
<i>Celtis pallida</i> Torr.	•	•	CB677, CB1106, CB655
CARYOPHYLLACEAE			
<i>Herniaria hirsuta</i> L.*		•	CB1244, CB1317
<i>Loeflingia squarrosa</i> Nutt.		•	CB1247

<i>Silene antirrhina</i> L.	•	•	CB1305, CB783, DG778
<i>Stellaria nitens</i> Nutt.	•		DK6100
CELASTRACEAE			
<i>Canotia holacantha</i> Torr.	•	•	DG823, DG831
CONVOLVULACEAE			
<i>Cuscuta indecora</i> Choisy		•	CB1182
<i>Cuscuta tuberculata</i> Brandeg.	•		DK5712, DK5705, DK5696
<i>Cuscuta umbellata</i> Kunth	•		DK5964, DK5775, DK5778
CRASSULACEAE			
<i>Crassula connata</i> (Ruiz & Pav.) Berger	•	•	CB798, CB1245
<i>Dudleya arizonica</i> Rose	•	•	CB1022, CB692, CB1312
CROSSOSOMATACEAE			
<i>Crossosoma bigelovii</i> S. Watson	•	•	CB678, CB591, CB1119
CUCURBITACEAE			
<i>Brandegea bigelovii</i> (S. Wats.) Cogn.	•	•	CB1204, CB1225
<i>Citrullus lanatus</i> (Thunb.) Matsum. & Nakai*		•	CB772, CS1 [DES]
<i>Cucurbita digitata</i> A. Gray	•		DK5769, DP5646
<i>Marah gilensis</i> Greene	•	•	CB1231
CYPERACEAE			
<i>Schoenoplectus americanus</i> (Pers.) Volk. ex Schinz & R. Keller	•	•	CB727
EPHEDRACEAE			
<i>Ephedra aspera</i> Engelm. ex S. Watson	•	•	DG795, CB867, CB676
<i>Ephedra trifurca</i> Torr. ex S. Watson	•	•	CB1242
EUPHORBIACEAE			
<i>Bernardia incana</i> Morton	•		DK6180 [UNM]
<i>Chamaesyce capitellata</i> (Engelm.) Millsp.	•		DK6311
<i>Chamaesyce florida</i> (Engelm.) Millsp.	•	•	CB1205
<i>Chamaesyce micromera</i> (Boiss. ex Engelm.) Woot. & Standl.	•	•	DG869, CB1069
<i>Chamaesyce revoluta</i> (Engelm.) Small	•	•	DG833
<i>Ditaxis lanceolata</i> (Benth.) Pax & K. Hoffmann	•	•	DG826, CB873, CB564
<i>Ditaxis neomexicana</i> (Müll.Arg.) A. Heller	•	•	CB1089, DG875
<i>Euphorbia abramsiana</i> L.C. Wheeler	•	•	DG862, CB1064
<i>Euphorbia arizonica</i> Engelm.	•	•	CB1123, DG849, CB1102
<i>Euphorbia eriantha</i> Benth.	•	•	CB1137, DG892, CB1282
<i>Euphorbia polycarpa</i> Benth.	•	•	CB637, DG681, DG630
<i>Euphorbia setiloba</i> Engelm. ex Torr.	•		DK5742
FABACEAE			
<i>Acmispon humistratus</i> (Benth.) D.D. Sokoloff	•	•	CB990, CB1291, DG788
<i>Acmispon maritimus</i> var. <i>brevivexillus</i> (Ottley) Brouillet	•	•	CB944, CB443, CB785
<i>Acmispon rigidus</i> (Benth.) Brouillet	•	•	CB996
<i>Acmispon strigosus</i> (Nutt.) Brouillet	•	•	CB977, CB1359, CB899
<i>Astragalus didymocarpus</i> Hook. & Arn.	•	•	200PS-K121-14 [ASU]
<i>Astragalus nuttallianus</i> DC.	•	•	CB1388, CB788, CB801
<i>Calliandra eriophylla</i> Benth.	•	•	DG885, DG824, CB1020
<i>Dalea mollis</i> Benth.		•	CB1452
<i>Dalea mollissima</i> (Rydb.) Munz	•		DK5911
<i>Lotus salsuginosus</i> Greene	•	•	CB885, DG626, DG740
<i>Lupinus arizonicus</i> (S. Wats.) S. Wats.	•	•	CB713, CB448, CB917
<i>Lupinus concinnus</i> J. G. Agardh	•	•	CB853
<i>Lupinus sparsiflorus</i> Benth.	•	•	CB792, CB1254, CB1026
<i>Lupinus succulentus</i> Douglas ex K. Koch		•	CB918, CB434
<i>Marina parryi</i> (Torr. & A. Gray) Barneby	•	•	CB657, CB1085, DG800
<i>Melilotus indicus</i> (L.) All.*	•	•	CB1017
<i>Olneya tesota</i> A. Gray	•	•	CB723, CB1051, CB711
<i>Parkinsonia florida</i> (Benth. ex A. Gray) S. Watson	•	•	CB556
<i>Parkinsonia microphylla</i> Torr.	•	•	CB679, CB476, DG636
<i>Prosopis velutina</i> Wooton	•	•	DG756, CB684, CB1287
<i>Senegalia greggii</i> (A. Gray) Britton and Rose	•	•	CB1048, CB539, CB1342
<i>Senna covesii</i> (A. Gray) Irwin & Barneby	•	•	CB863, CB709, DG652

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<i>Trifolium willdenovii</i> Spreng.	•	•	CB986, CB1283
<i>Vachellia constricta</i> (Benth.) Seigler & Ebinger	•	•	DG670, CB1057
FAGACEAE			
<i>Quercus turbinella</i> Greene	•	•	CB680
FOUQUIERIACEAE			
<i>Fouquieria splendens</i> Engelm.	•	•	CB980, DG724, CB537
GENTIANACEAE			
<i>Zeltnera calycosa</i> (Buckley) G. Mans.		•	CB642
GERANIACEAE			
<i>Erodium cicutarium</i> (L.) L'Hér. ex Aiton*	•	•	DG735, CB805, CB1378
<i>Erodium texanum</i> A. Gray	•	•	CB844, CB734, DG728
JUNCACEAE			
<i>Juncus bufonius</i> L.	•	•	CB1024, CB1303, CB1015
<i>Juncus torreyi</i> Coville		•	CB728
KRAMERIACEAE			
<i>Krameria bicolor</i> S. Watson	•	•	CB524, DG646, CB1288
<i>Krameria erecta</i> Willd. ex J.A. Schultes	•	•	CB1406, DG815, CB1043
LAMIACEAE			
<i>Hedeoma nana</i> (Torr.) Briq.	•		DK4785, DK6184
<i>Hyptis emoryi</i> Torr.	•	•	CB486, DG661, DG744
<i>Salazaria mexicana</i> Torr.	•	•	CB626, CB1056, CB687
<i>Salvia columbariae</i> Benth.	•	•	CB433, CB1120, CB1001
LILIACEAE			
<i>Calochortus kennedyi</i> Porter	•	•	CB1391, DG813, CB988
LINACEAE			
<i>Linum grandiflorum</i> Desf.*		•	CS3 [DES]
LOASACEAE			
<i>Mentzelia affinis</i> Greene	•	•	ZB2017-03-18 [SEINet Obser.]
<i>Mentzelia involucrata</i> S. Watson	•	•	WH30708 [DES]
<i>Mentzelia jonesii</i> (Urban & Gilg) H.J. Thompson & Roberts	•		DK4101
MALPIGHIACEAE			
<i>Cottisia gracilis</i> (A. Gray) W.R. Anderson	•	•	DG791, CB457, DG651
MALVACEAE			
<i>Abutilon abutiloides</i> (Jacq.) Garcke ex Britt. & Wilson		•	CB770
<i>Abutilon incanum</i> (Link) Sweet	•	•	CB569, DG641, CB1227
<i>Abutilon palmeri</i> A. Gray	•	•	CB1323, DG904
<i>Abutilon parvulum</i> A. Gray	•		DK4748-b
<i>Ayenia compacta</i> Rose		•	DS2017-April-7 [SEINet Obser.]
<i>Ayenia filiformis</i> S. Watson	•	•	CB573, DG852, CB634
<i>Eremalche exilis</i> (A. Gray) Greene	•	•	CB841
<i>Herissantia crispa</i> (L.) Briz.	•	•	CB567, DG782, DG692
<i>Hibiscus coulteri</i> Harvey ex A. Gray	•	•	CB1219
<i>Hibiscus demudatus</i> Benth.	•	•	CB574
<i>Horsfordia newberryi</i> (S. Wats.) A. Gray	•	•	CB1154, CB430, DG694
<i>Malva neglecta</i> Wallr.*	•	•	CB1285, CB1294
<i>Malva parviflora</i> L.*	•	•	DG715, CB824
<i>Sphaeralcea ambigua</i> A. Gray	•	•	CB541, CB1270, DG801
<i>Sphaeralcea coulteri</i> (S. Watson) A. Gray	•	•	CB821
<i>Sphaeralcea emoryi</i> Torr. ex A. Gray	•	•	CB1118, CB1257
MARTYNIACEAE			
<i>Proboscidea altheifolia</i> (Benth.) Decne.	•	•	CB1189
<i>Proboscidea parviflora</i> (Wooton) Wooton & Standl.	•		DK5788
MOLLUGINACEAE			
<i>Mollugo cerviana</i> (L.) Ser.	•		DK5633, DK5768, DK5693
MONTIACEAE			
<i>Calandrinia ciliata</i> (Ruiz & Pav.) DC.	•	•	DG726, CB830, CB889
<i>Cistanthe monandra</i> (Nutt.) Hershkovitz	•	•	DG759
<i>Claytonia perfoliata</i> Donn ex Willd.		•	CB1040
NYCTAGINACEAE			

<i>Abronia villosa</i> S. Watson	•	CB501
<i>Allionia choisyi</i> Standl.	•	DG863
<i>Allionia incarnata</i> L.	•	CB1218, CB1371, CB999
<i>Boerhavia coccinea</i> P. Mill.	•	CB1012, DG662, CB1076
<i>Boerhavia coulteri</i> (Hook. f.) S. Wats.	•	CB1499, CB1500
<i>Boerhavia intermedia</i> M.E.Jones	•	DG859, CB1065, CB759A
<i>Boerhavia wrightii</i> A. Gray	•	DK5641, DK5756, DK5697
<i>Mirabilis coccinea</i> (Torr.) Benth. & Hook. f.	•	CB1045
<i>Mirabilis laevis</i> (Benth.) Curran	•	CB1047, CB834, CB1372
NYMPHAEACEAE		
<i>Nymphaea mexicana</i> Zucc.	•	CB730
OLEACEAE		
<i>Forestiera shrevei</i> Standl.	•	CB1421
<i>Menodora scabra</i> A. Gray	•	DG901, CB985, CB621
ONAGRACEAE		
<i>Chylismia claviformis</i> (Torr. & Frém.) A. Heller	•	CB836, DG755
<i>Eremothera boothii</i> (Douglas) W.L. Wagner & Hoch	•	CB1463
<i>Eremothera chamaenerioides</i> (A. Gray) W.L. Wagner & Hoch	•	DK4075, DK4109, DK3044
<i>Eulobus californicus</i> Nutt. ex Torr. & A. Gray	•	CB802, DG633, DG751
<i>Oenothera primiveris</i> A. Gray	•	CB817
OROBANCHACEAE		
<i>Castilleja exserta</i> (Heller) Chuang & Heckard	•	CB1307, CB804, CB1279
<i>Castilleja lanata</i> A. Gray	•	DK4557, DK4195, DK4144
<i>Orobanche cooperi</i> (A. Gray) Heller	•	CB1289, CS4 [DES]
PAPAVERACEAE		
<i>Eschscholzia californica subsp. mexicana</i> (Greene) C. Clark	•	DG890, DG712, CB866
<i>Eschscholzia minutiflora</i> S. Watson	•	CS5 [DES]
PHRYMACEAE		
<i>Erythranthe guttata</i> (Fisch. ex DC.) G. L. Nesom	•	CB643, CB701, CB1306
PLANTAGINACEAE		
<i>Keckiella antirrhinoides</i> (Benth.) Straw	•	CB656, CB632, DG806
<i>Maurandya antirrhiniflora</i> Humb. & Bonpl. ex Willd	•	DK4222
<i>Nuttallanthus texanus</i> (Scheele) D. A. Sutton	•	CB842
<i>Penstemon parryi</i> (A. Gray) A. Gray	•	CB708
<i>Penstemon subulatus</i> M.E. Jones	•	CB1380, DG821
<i>Plantago ovata</i> Forssk.	•	DG725, CB849, CB446
<i>Plantago patagonica</i> Jacq.	•	DG687, CB1362, CB943
<i>Sairocarpus nuttallianus</i> (Benth. ex A. DC.) D.A. Sutton	•	CB1281, CB1009, CB1423
<i>Stemodia durantifolia</i> (L.) Sw.	•	DK6226
<i>Veronica peregrina</i> L.	•	CB1269
POACEAE		
<i>Aristida adscensionis</i> L.	•	DG625, CB1061, CB763
<i>Aristida purpurea</i> Nutt.	•	CB1215
<i>Aristida purpurea</i> var. <i>nealleyi</i> (Vasey) Allred	•	DG683, CB1340, CB562
<i>Aristida purpurea</i> var. <i>parishii</i> (A.S. Hitchc.) Allred	•	DK3170, DK5745, DK4563
<i>Aristida ternipes</i> Cav.	•	DK6301
<i>Avena fatua</i> L.*	•	CB653, CB1302, CB576
<i>Bothriochloa barbinodis</i> (Lag.) Herter	•	CB1348
<i>Bouteloua aristidoides</i> (Kunth) Griseb.	•	CB1067, DG881, DG867
<i>Bouteloua barbata</i> Lag.	•	CB1068, DG866
<i>Bouteloua curtipendula</i> (Michx.) Torr.	•	CB1493
<i>Bouteloua trifida</i> Thurb.	•	DK5736, DK3990, DK4792
<i>Bromus arizonicus</i> (Shear) Stebbins	•	CB1271, CB1032, CB810
<i>Bromus marginatus</i> Nees ex Steud.	•	CB602
<i>Bromus rubens</i> L.*	•	DG665, CB1363, DG769
<i>Cenchrus ciliaris</i> L.*	•	DG842, DG734, CB1381
<i>Cenchrus setaceus</i> (Forssk.) Morrone*	•	CB1212, CB1146, CB544
<i>Chloris virgata</i> Sw.	•	DK6270
<i>Cynodon dactylon</i> (L.) Pers.*	•	CB1318, CB1131, CB603

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<i>Dasyochloa pulchella</i> (Kunth) Willd. ex Rydb.	•	•	CB500, CB1222, CB721
<i>Digitaria californica</i> (Benth.) Henr.	•		DK4003, DK5987, DK4014
<i>Diplachne fusca</i> subsp. <i>uninervia</i> (J. Presl) P. M. Peterson & N. Snow	•		DK6000, DK6230
<i>Eragrostis cilianensis</i> (All.) Vignolo ex Janch.*	•		DK5778
<i>Eragrostis lehmanniana</i> Nees*		•	CB1343, CB1384
<i>Heteropogon contortus</i> (L.) Beauv. ex Roemer & J.A. Schultes	•	•	CB1427, CB768, CB1344
<i>Hilaria mutica</i> (Buckley) Benth.	•	•	CB907
<i>Hilaria rigida</i> (Thurb.) Benth. ex Scribn.	•	•	CB577, CB673, CB485
<i>Hordeum murinum</i> L.*	•	•	CB1273, CB1382, DG738
<i>Leptochloa panicea</i> subsp. <i>brachiata</i> (Steudl.) N. Snow	•	•	CB762, CB1082
<i>Melica frutescens</i> Scribn.	•	•	CB693
<i>Muhlenbergia microsperma</i> (DC.) Trin.	•	•	CB766, CB1023, CB484
<i>Muhlenbergia porteri</i> Scribn. ex Beal	•	•	DG880, CB1234
<i>Muhlenbergia rigens</i> (Benth.) A.S. Hitchc.	•		DK4601
<i>Panicum alatum</i> var. <i>minus</i> (Andersson) F. Zuloaga & O. Morrone	•		DK5793
<i>Panicum hirticaule</i> J. Presl	•	•	CB1444
<i>Pappostipa speciosa</i> (Trin. & Rupr.) Romasch.	•	•	DG822, DG822
<i>Phalaris caroliniana</i> Walter	•		DK6304
<i>Phalaris minor</i> Retz.*	•	•	CB1301, CB1014, CB1433
<i>Poa bigelovii</i> Vasey & Scribn.	•	•	CB897, CB811, CB1243
<i>Polypogon monspeliensis</i> (L.) Desf.*	•	•	CB1349, CB1025, CB660
<i>Polypogon viridis</i> (Gouan) Breistr.*	•		DK4739
<i>Schismus arabicus</i> Nees*	•	•	CB1059, DG624, CB900
<i>Schismus barbatus</i> (Loefl. ex L.) Thellung*	•	•	CB945, CB658, CB854
<i>Setaria leucopila</i> (Scribn. & Merr.) K. Schum.	•		DK6302
<i>Sporobolus airoides</i> (Torr.) Torr.	•	•	CB1213, CB1080, CB1211
<i>Sporobolus contractus</i> A.S. Hitchc.	•		DK5663
<i>Tridens muticus</i> (Torr.) Nash	•	•	CB1217
<i>Urochloa arizonica</i> (Scribn. & Merr.) O. Morrone & F. Zuloaga	•	•	CB767, CB1216
<i>Vulpia microstachys</i> (Nutt.) Munro	•	•	CB989, CB1292
<i>Vulpia octoflora</i> (Walter) Rydb.	•	•	CB819
<i>Vulpia octoflora</i> var. <i>hirtella</i> (Piper) Henr.	•	•	CB904, CB978
POLEMONIACEAE			
<i>Eriastrum diffusum</i> (A. Gray) Mason	•	•	DG779, DG761
<i>Eriastrum eremicum</i> (Jepson) Mason	•	•	CB909, CB587, CB1387
<i>Gilia flavocincta</i> A. Nels.	•	•	CB1255, DG839, CB933
<i>Gilia scopulorum</i> M.E. Jones		•	CB705
<i>Gilia stellata</i> Heller	•	•	CB1132, CB478, CB1157
<i>Linanthus bigelovii</i> (A. Gray) Greene	•	•	CB908, CB831, CB832
<i>Linanthus maricopensis</i> J.M.Porter & R.Patt.	•	•	DK4059, GBIF ¹
POLYGALACEAE			
<i>Polygala macradenia</i> A. Gray	•		DK6121
POLYGONACEAE			
<i>Chorizanthe brevicornu</i> Torr.	•	•	CB695, CB450, CB946
<i>Chorizanthe rigida</i> (Torr.) Torr. & A. Gray	•	•	CB947, DG650, CB859
<i>Eriogonum deflexum</i> Torr.	•	•	CB733, CB756, DG702
<i>Eriogonum fasciculatum</i> Benth.	•	•	CB623, CB1052, DG844
<i>Eriogonum inflatum</i> Torr. & Frém.	•	•	CB474
<i>Eriogonum pusillum</i> Torr. & A. Gray		•	CB1466
<i>Eriogonum trichopes</i> Torr.	•	•	CB1461
<i>Eriogonum wrightii</i> Torr. ex Benth.	•	•	CB1238, DG902, CB1221
<i>Pterostegia drymarioides</i> Fisch. & C.A. Mey.	•	•	CB1399
PORTULACACEAE			
<i>Portulaca oleracea</i> L.	•		DK5950, DK5963
PRIMULACEAE			
<i>Androsace occidentalis</i> Pursh	•		DK2912, DK6217, DK3151
PTERIDACEAE			
<i>Astrolepis cochisensis</i> (Goodding) Benham & Windham	•	•	CB1426
<i>Astrolepis sinuata</i> (Lag. ex Sw.) Benham & Windham	•	•	CB1209

<i>Myriopteris covillei</i> (Maxon) Á.Löve & D.Löve	•	•	CB1490
<i>Myriopteris lindheimeri</i> (Hook.) J. Sm.	•	•	CB689
<i>Myriopteris parryi</i> (D. C. Eaton) Grusz & Windham	•	•	DG874, DG807, DG730
<i>Myriopteris wrightii</i> (Hook.) Grusz & Windham	•		DK4094, DK2906, DK6252
<i>Notholaena californica</i> D. C. Eaton	•		DK4024, DK3137, DK6134
<i>Notholaena standleyi</i> Maxon	•	•	DG870, DG792, DG697
<i>Pellaea truncata</i> Goodding	•	•	CB1428, CB595, CB995
<i>Pentagramma triangularis</i> (Kaulf.) Yatsk., Windham & E. Wollenw.	•	•	CB1127, CB1041
RANUNCULACEAE			
<i>Anemone tuberosa</i> Rydb.	•	•	CB905
<i>Clematis drummondii</i> Torr. & A. Gray	•	•	CB641
<i>Delphinium parishii</i> A. Gray	•	•	CB987, CB1003
<i>Delphinium scaposum</i> Greene	•	•	CB1008, DG784, CB1263
<i>Myosurus cupulatus</i> S. Wats.	•		DK6102
RESEDACEAE			
<i>Oligomeris linifolia</i> (Vahl) J.F. Macbr.	•		DK3165
RHAMNACEAE			
<i>Ziziphus obtusifolia</i> (Hook. ex Torr. & A. Gray) A. Gray	•	•	CB1398, CB670
RUBIACEAE			
<i>Galium aparine</i> L.	•	•	DG803, CB596, CB1432
<i>Galium proliferum</i> A. Gray	•	•	CB1125
<i>Galium stellatum</i> Kellogg	•	•	CB1142, CB622, CB489
SALICACEAE			
<i>Populus fremontii</i> S. Watson	•		DKsn
<i>Salix exigua</i> Nutt.	•		DK3988
<i>Salix gooddingii</i> C.R. Ball	•	•	CB1345, CB1420, CB654
SANTALACEAE			
<i>Phoradendron californicum</i> Nutt.	•	•	CB568, DG648, CB1101
SELAGINELLACEAE			
<i>Selaginella arizonica</i> Maxon	•	•	DG698, DG731
<i>Selaginella eremophila</i> Maxon	•		DK4088, DK2878
SIMMONDSIACEAE			
<i>Simmondsia chinensis</i> (Link) Schneid.	•	•	DG672, DG654, DG644
SOLANACEAE			
<i>Datura discolor</i> Bernh.	•	•	CB1229
<i>Lycium andersonii</i> A. Gray	•	•	DG643, CB881, CB523
<i>Lycium berlandieri</i> Dunal	•	•	DG898, DG871, DG834
<i>Lycium exsertum</i> A. Gray	•	•	CB1094, CB1136, DG673
<i>Lycium fremontii</i> A. Gray	•	•	CB1430, DG783, CB1220
<i>Nicotiana clevelandii</i> A. Gray		•	CB833
<i>Nicotiana obtusifolia</i> M. Martens & Galeotti	•	•	CB645, CB550, CB1095
<i>Physalis crassifolia</i> Benth.	•	•	CB1233
<i>Physalis hederifolia</i> A. Gray		•	CB1034
<i>Solanum elaeagnifolium</i> Cav.	•		DK5650
TALINACEAE			
<i>Talinum aurantiacum</i> Engelm.		•	CB1498
TAMARICACEAE			
<i>Tamarix chinensis</i> Lour.*	•	•	CB1396, CB1077, CB663
TYPHACEAE			
<i>Typha domingensis</i> Pers.	•	•	CB732
URTICACEAE			
<i>Parietaria hespera</i> Hinton	•	•	CB547, DG812, CB912
VERBENACEAE			
<i>Aloysia wrightii</i> Heller ex Abrams	•	•	DG830
ZYGOPHYLLACEAE			
<i>Fagonia laevis</i> Standl.	•	•	CB888, DG793, CB429
<i>Kallstroemia californica</i> (S. Watson) Vail	•		DK5766, DK5704, DK5777
<i>Kallstroemia grandiflora</i> Torr. ex A. Gray	•	•	CB1091
<i>Kallstroemia parviflora</i> J. B. S. Norton	•	•	CB1208, DG864, CB1180

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<i>Larrea tridentata</i> (Sessé & Moc. ex DC.) Coville	•	•	CB682, CB488, DG635
<i>Tribulus terrestris</i> L.*	•		DK5715

*Indicates non-native status

¹iNaturalist contributors, iNaturalist (2022). iNaturalist Research-grade Observations. INaturalist.org.

Occurrence dataset <https://doi.org/10.15468/ab3s5x> accessed via GBIF.org on 2022-10-30.

<https://www.inaturalist.org/observations/5283602>.

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VASCULAR PLANT CHECKLIST OF COAL MINE CANYON, SANTA CRUZ COUNTY, ARIZONA

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ABSTRACT: A checklist of vascular plants is provided for Coal Mine Canyon and lower Ash Canyon in central Santa Cruz County, Arizona. The documented flora includes 584 species (plus 5 additional infraspecific taxa) in 360 genera and 93 families. The largest families are Asteraceae, Poaceae, and Fabaceae; the largest genera are *Muhlenbergia*, *Euphorbia*, *Cyperus*, *Bouteloua*, and *Dalea*. Non-native plants number 28, of which 18 are grasses. *Heliotropium hartwegianum* (Heliotropiaceae) is a new record for the United States.

STUDY AREA

The study area comprises 1,743 hectares (17.43 sq km; 4,307 acres) in the Grosvenor Hills in central Santa Cruz County, Arizona (Figure 1). The property was purchased by Arizona Game and Fish Department (AZGFD) between 2004 and 2006 (Trust for Public Land 2006). It is managed by Arizona State Parks for threatened and endangered species habitat, as well as recreation, as part of Sonoita Creek State Natural Area (SCSNA). The approximate center of the Coal Mine Canyon property lies at 31.54, -110.89, about 23.5 km (14.6 mi) north of the U.S.–Mexico border. It is bordered to the west, north, and east by Salero Ranch; its southern boundary meets SCSNA on the west and private land on the east. Patagonia Lake State Park is located 2.5 km (1.6 mi) to the south-southeast.

The landscape is heavily dissected, with rocky ridges and hills and numerous drainages. Coal Mine Canyon originates in the Grosvenor Hills and bends in a broad arc east, south, and southwestward before entering SCSNA, where it joins with Fresno Canyon and flows south to Sonoita Creek. Ash Canyon originates in the southern Santa Rita Mountains and runs down the east side of the study area, eventually emptying into Patagonia Lake, a dammed reservoir along Sonoita Creek. There are three named perennial springs—Coal Mine Spring along Coal Mine Canyon and George Wise and Mata Siete springs along Ash Canyon—and several unnamed and unmapped springs. Two cement-dammed ponds and a few dirt-dammed ponds were formerly used for cattle. Vehicular access is limited to two unmaintained roads entering from private land on Salero Ranch.

Elevations range from 1,200 m (3,940 ft) to 1,666 m (5,466 ft), a difference of 466 m (1,529 ft). The lowest elevations occur in Ash and Coal Mine canyons where they drain southward out of the study area.



Figure 1. Study area showing major canyons and springs. Map by Sue Rutman.

GEOLOGY

The geology of the Coal Mine Canyon property is volcanic in origin, composed primarily of rhyolite and rhyodacite, along with tuff, breccia, conglomerate, agglomerate, and pyroclastic sandstone (Drewes 1968, 1972a). Squaw Gulch Granite, dating to 145–160 million years ago, underlies the area. The Salero Formation (late Cretaceous, 72 million years ago) consists of tuffaceous sandstone, conglomerate and tuffaceous breccia; it overlies Squaw Gulch Granite and can be seen in the northeast part of the study area near Cieneguita Canyon (Drewes 1968).

Most of the visible rocks on the Coal Mine Canyon property are part of the Grosvenor Hills Volcanics, formed in the Oligocene (about 25 million years ago) when a large volcano erupted west of the Coal Mine area near the present-day San Cayetano Mountains (Drewes 1972a). These volcanics include layers of rhyolite tuff and tuff breccia, on top of which lie ridges of rhyodacite agglomerates and tuff (Drewes 1972a). The Grosvenor Hills, which dominate the study area, are notable for a series of laccoliths, erosion-resistant lenses of rhyodacite vitrophyre that intruded into the volcanic layers from below; the southernmost of these laccoliths lies near George Wise Spring in the southeast corner of the study area (Drewes 1972b).

The study area is part of a large block or graben that was displaced downward 450–750 m relative to the San Cayetano Mountains. In addition, a single graben about 1 km wide runs across the middle of the Coal Mine property; it is bordered to the north by the Sheuy Fault and to the south by the George Wise Fault (Drewes 1972b). Many small, north-south faults occur near Coal Mine Spring in the southwest part of the property (Drewes 1972a). These faults and associated fracturing likely contributed to the presence of numerous natural springs.

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Figure 2. Satellite imagery of Coal Mine Spring along Coal Mine Canyon; image date 29 Jul 2021.



Figure 3. Satellite imagery of George Wise Spring along Ash Canyon; image date 29 Jul 2021.

CLIMATE

The study area has a semiarid climate with bimodal (winter–spring and summer–fall) precipitation. Long-term climate data from a station in Rio Rico, six miles southwest of the study area, show an average annual rainfall of 409 mm (16.1 in) between 1991 and 2020 (<https://www.ncei.noaa.gov/access/us-climate-normals/>). Sixty percent of this precipitation occurred in monsoonal thunderstorms during July, August, and September. Winter precipitation usually derives from Pacific frontal systems and is less reliable but more widespread. The driest months are April and May. The 30-year average maximum temperature for June, July, and August is 34.7°C (94.4°F); the average minimum temperature for December, January, and February is -1.7°C (28.9°F).

HISTORY AND LAND USE

Coal Mine Canyon and surrounding lands have been inhabited for several millennia. Prehistoric artifacts and occupation sites from the Late Archaic (2000 BC) and Hohokam (1–1400 AD) periods were documented at Coal Mine and George Wise springs (Moss 2010, Moss et al. 2010). By the sixteenth century, the Santa Cruz River Valley was inhabited by the O’odham (Sheridan 2004). In the late seventeenth century, Jesuit missionaries arrived in the area, bringing with them cattle and other livestock.

In 1860, the U.S. Congress established Baca Float No. 3 (one of five 100,000-acre land grants to a New Mexico sheep ranching family) between the Santa Cruz River Valley and the southern Santa Rita Mountains. The northeast corner of the float, including the Grosvenor Hills and Ash and Coal Mine canyons, would become the Salero Ranch (Sheridan 2004, Carnahan 2020). Between 2004 and 2006, the 1,734-hectare Coal Mine Canyon property was purchased by Arizona Game and Fish Department with the goal of preserving native grassland and aquatic habitat for threatened and endangered species such as the Gila topminnow (*Poeciliopsis occidentalis* [S.F. Baird & Girard, 1853]). See Trust for Public Land (2006) for details about the acquisition.

As part of the Salero Ranch, the Coal Mine Canyon property was grazed seasonally by cattle. After the purchase by AZGFD, perimeter fencing was installed, but trespass cattle began entering via breaks in the fence, especially along the southern boundary. Rigid pipe fencing was erected to protect George Wise and Coal Mine springs from cattle, but the unpermitted grazing continued elsewhere until AZGFD and the Arizona Attorney General’s office intervened in 2021. By summer 2022, several hundred trespass cattle had been removed from the study area.

I found no record of herbarium specimens from the Coal Mine Canyon property prior to this study. The nearest collections are represented in floras of Sonoita Creek State Natural Area (McLaughlin 2006) and Salero Ranch (Carnahan 2020).

VEGETATION

The dominant vegetative community is scrub or semi-desert grassland, which is characterized by perennial grasses, herbaceous plants, stem succulents, and woody shrubs and trees. Common grasses include cane beardgrass (*Bothriochloa barbinodis*), grama grasses (*Bouteloua* species), Lehmann lovegrass (*Eragrostis lehmanniana*), and muhly grasses (*Muhlenbergia* species). Characteristic shrubs are desert hackberry (*Celtis pallida*), kidneywood (*Eysenhardtia orthocarpa*), ocotillo (*Fouquieria splendens*), catclaw and velvetpod mimosas (*Mimosa aculeaticarpa* and *M. dysocarpa*), and graythorn

VASCULAR PLANT CHECKLIST OF COAL MINE CANYON

(*Sarcomphalus obtusifolius*). Velvet mesquite (*Prosopis velutina*) occurs throughout the study area. Emoryi oak (*Quercus emoryi*) and Arizona juniper (*Juniperus arizonicus*) are occasional in the grassland; Mexican blue oak (*Quercus oblongifolia*) is found on north-facing slopes, where the grassland gives way to pockets of oak woodland. Canyons, perennial springs, and cattle ponds support riparian species such as seep willow (*Baccharis salicifolia*), velvet ash (*Fraxinus velutina*), deergrass (*Muhlenbergia rigens*), Fremont cottonwood (*Populus fremontii*), and Goodding willow (*Salix gooddingii*).



Figure 4. (A) Coal Mine Spring, 18 Nov 2021; (B) George Wise Spring, 27 May 2020; (C) Grosvenor Hills between Cieneguita and Coal Mine canyons, 15 Oct 2020; (D) Rock overhang shelter near unmapped spring in Grosvenor Hills; the blackened ceiling suggests prehistoric use, but this remote site was probably not surveyed by Moss et al. (2010); 1 Apr 2020.



Figure 5. (A) *Asclepias linaria* (Apocynaceae), 20 Apr 2022; (B) *Mammillaria macdougalii* (Cactaceae), 5 Apr 2020; (C) *Tephrosia leiocarpa* (Fabaceae), 20 Aug 2021; (D) *Heteranthera limosa* (Pontederiaceae), 31 Aug 2021.

FLORISTICS

The vascular flora of the study area comprises 584 species (plus 5 additional infraspecific taxa) in 360 genera and 93 families. There are 20 pteridophytes, 2 gymnosperms, 1 magnoliid, 433 eudicots, and 128 monocots. The largest families are Asteraceae (96 taxa at or below species level), Poaceae (86), Fabaceae (54), Euphorbiaceae (20), and Pteridaceae (17). The most species-rich genera are *Muhlenbergia* (14 species), *Euphorbia* (13), *Cyperus* (12), *Bouteloua* (11), and *Dalea* (8). Non-natives number 28 (5% of the total flora); 18 of these are grasses.

COMPARISON WITH NEARBY FLORAS

Table 1 compares the taxa counts, study area size and elevation, vegetative communities, and survey effort for the floras of Coal Mine Canyon, Salero Ranch (Carnahan 2020), and Sonoita Creek State Natural Area (SCSNA; McLaughlin 2006). The Coal Mine Canyon property is surrounded on three sides by Salero Ranch, so the two floras have much in common botanically. The higher taxa count of Salero Ranch is likely due to the larger study area, greater elevation range (reaching into oak-pinyon woodland), and collecting effort. At least fifty species found on Salero and not on Coal Mine occur primarily in oak woodland or higher; examples are *Pinus discolor* (Pinaceae), *Verbesina longifolia*

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(Asteraceae), and *Arctostaphylos pungens* (Ericaceae). Salero also had a higher percentage of non-native plants, probably because of its long history of human use, including custom home development since 1998 (Carnahan 2020).

<i>Flora</i>	<i>Total taxa*</i>	<i>Non-native %</i>	<i>Study area size (ha)</i>	<i>Elevation range (m)</i>	<i>Vegetative community</i>	<i>Effort (yrs)</i>	<i>Effort (trips)</i>	<i>Public/private</i>
Salero Ranch ¹	796**	9.8**	6541	784	Grassland to oak-pinyon woodland	6.5	360+	private
Coal Mine Canyon	589	4.8	1743	466	Grassland	3	72	public
Sonoita Creek State Natural Area ²	561	6.4	1990	230	Grassland	1.4	34	public

Table 1. Comparison of the floras of Coal Mine Canyon, Salero Ranch, and Sonoita Creek State Natural Area.

¹Carnahan 2020; ²McLaughlin 2006.

*species plus additional infraspecific taxa

**updated (since publication) with the addition of 6 native and 2 non-native species

Coal Mine shares many species with SCSNA, which borders it to the southwest. The two floras are similar in total number of taxa, study area size, and vegetative communities; they differ in elevation range and collecting effort.

Six species found on the Coal Mine Canyon property were not documented on either Salero Ranch or SCSNA: *Myriopteris yavapensis* (Pteridaceae), *Euphorbia stictospora* (Euphorbiaceae), *Anagallis minima* (Primulaceae), *Lemna minuta* (Araceae), *Eleocharis parishii* (Cyperaceae), and *Paspalum setaceum* (Poaceae). In contrast, five species that occurred on both Salero Ranch and SCSNA were not found for Coal Mine: *Echinocereus fendleri* (Cactaceae), *Croton pottsii* (Euphorbiaceae), *Senna bauhinioides* (Fabaceae), *Lythrum californicum* (Lythraceae), and *Sorghum halepense* (Poaceae). Floras are always incomplete; many of these species might eventually be documented in all three study areas.

RARE AND INTERESTING PLANTS

Heliotropium hartwegianum [*Tournefortia hartwegiana*] (Heliotropiaceae) is a new record for the United States (Figure 6). This shrub-sized herbaceous perennial is otherwise endemic to Mexico. Approximately 200 plants were found on rocky, grassland slopes in the southwest part of the study area and on adjacent Salero Ranch. Several hundred more were found in nearby Fresno Canyon in SCSNA (Carnahan 5065, SEINet). Flowering was observed from December to February, but many of the plants had frost-killed leaves and inflorescences. These populations may be a relatively recent arrival, as McLaughlin (2006) did not report them for SCSNA. See Halse and Feuillet (2022) for nomenclature.



Figure 6. *Heliotropium hartwegianum* (Heliotropiaceae): (A) Vegetative growth, 17 August 2021; (B) Frost-nipped flowering stem, 17 February 2022; (C) Flowering in Álamos, Sonora, 18 Dec 2015; (D) Habitat in study area, 17 Aug 2021.

New localities were also found for regionally rare or uncommon species: *Matelea tristiflora* (Apocynaceae), *Phacelia sonoitensis* (Hydrophyllaceae), *Rotala ramosior* (Lythraceae), *Sida glabra* (Malvaceae), *Phyllanthus polygonoides* (Phyllanthaceae), *Houstonia prostrata* (Rubiaceae), and *Muhlenbergia palmeri* (Poaceae). See Figure 7.

VASCULAR PLANT CHECKLIST OF COAL MINE CANYON

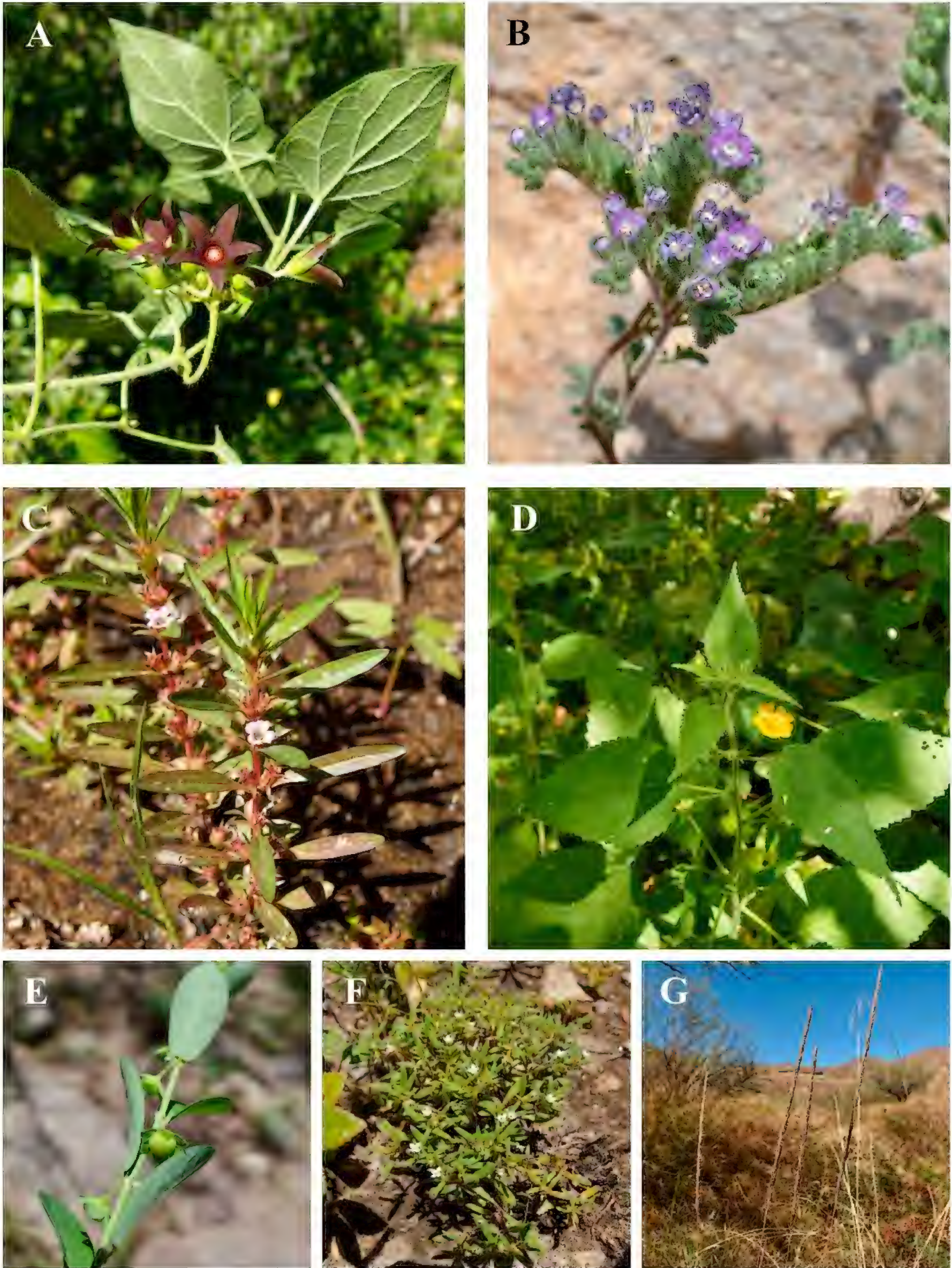


Figure 7. (A) *Matelea tristiflora* (Apocynaceae); (B) *Phacelia sonoitensis* (Hydrophyllaceae); (C) *Rotala ramosior* (Lythraceae); (D) *Sida glabra* (Malvaceae); (E) *Phyllanthus polygonoides* (Phyllanthaceae); (F) *Houstonia prostrata* (Rubiaceae); (G) *Muhlenbergia palmeri* (Poaceae).

METHODS

Most fieldwork took place between fall 2019 and fall 2022, under permits from Arizona Game and Fish Department and Arizona State Parks. I visited the property 72 times and made more than 700 collections. Specimens were deposited in the University of Arizona Herbarium (ARIZ), with duplicates when available sent to regional herbaria in Arizona and Sonora, Mexico, including ASC, ASU, DES, and USON (Thiers 2023). A duplicate of *Heliotropium hartwegianum* (Carnahan 5067) was sent to Oregon State University Herbarium (OSC) for verification by Richard Halse. Two cactus species, *Echinocereus santaritensis* and *Mammillaria grahamii*, were documented with image vouchers on the SEINet Portal Network (SEINet 2023); all collection records and many photographs can be viewed on SEINet. Two additional species were observed but not found in collectible condition during the study period: *Asclepias elata* (Apocynaceae) and *Rumex* cf. *hymenosepalus* (Polygonaceae); they are excluded from the checklist and taxa counts.

Identifications were supported by information from SEINet (2023), Vascular Plants of Arizona (Vascular Plants of Arizona Editorial Committee 1992+), Flora of North America (Flora of North America Editorial Committee 1993+), and *Flora Neomexicana III* (Allred et al. 2020). Native status was obtained from The PLANTS Database of the U.S. Department of Agriculture (<https://plants.usda.gov/home>), with adjustments for Mexican species such *Macroptilium gibbosifolium* (Fabaceae) that are considered native to Arizona by regional botanists.

VASCULAR PLANT CHECKLIST

The following checklist includes selected synonyms. Non-native species are marked with an asterisk (*). Italicized numerals following each taxon name are Carnahan collection numbers.

PTERIDOPHYTES**MARSILEACEAE**

Marsilea mollis B. L. Rob. & Fernald. 4216

PTERIDACEAE

Argyroschisma incana (C. Presl) Windham. 4010

Argyroschisma limitanea (Maxon) Windham subsp. *limitanea*. 4981

Astrolepis cochisensis (Goodd.) D. M. Benham & Windham. 4415

Astrolepis integerrima (Hook.) D. M. Benham & Windham. 4826

Astrolepis sinuata (Lag. ex Sw.) D. M. Benham & Windham subsp. *sinuata*. 4310

Bommeria hispida (Mett. ex Kuhn) Underw. 4208

Myriopteris fendleri E. Fourn. 4581

Myriopteris lindheimeri J. Sm. 4084

Myriopteris rufa Fée. 4064

Myriopteris wootonii (Maxon) Grusz & Windham. 4207

Myriopteris wrightii (Hook.) Grusz & Windham. 3956

Myriopteris yavapensis (T. Reeves ex Windham) Grusz & Windham. 4545

Notholaena grayi Davenp. 4103

Notholaena standleyi Maxon. 4097

Pellaea intermedia Mett. ex Kuhn. 4544

Pellaea truncata Goodd. 3957

Pellaea wrightiana Hook. 4011

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SELAGINELLACEAE

Selaginella rupincola Underw. 4062

WOODSIACEAE

Woodsia cochisensis Windham. 4180, 4940

GYMNOSPERMS

CUPRESSACEAE

Juniperus arizonica (R. P. Adams) R. P. Adams. 4658, 5071

Juniperus deppeana Steud. 4344

MAGNOLIDS

ARISTOLOCHIACEAE

Aristolochia watsonii Wooton & Standl. 4600

EUDICOTS

ACANTHACEAE

Anisacanthus thurberi (Torr.) A. Gray. 4190, 5101

Carlowrightia arizonica A. Gray. 5112

Elytraria imbricata (Vahl) Pers. 4184

Tetramerium nervosum Nees. 4271

ADOXACEAE (*Sambucus*), see **VIBURNACEAE**

AIZOACEAE

Trianthema portulacastrum L. 4784

AMARANTHACEAE

Amaranthus palmeri S. Watson. 4371

Amaranthus torreyi (A. Gray) Benth. ex S. Watson. 3965

Atriplex canescens (Pursh) Nutt. 4843, 4860

Atriplex elegans (Moq.) D. Dietr. 4804

Chenopodium arizonicum Standl. 3955

Froelichia arizonica Thornber ex Standl. 4627

Gomphrena caespitosa Torr. 4182

Gomphrena nitida Rothr. 4450

Gomphrena sonora Torr. 4395

Guilleminea densa (Willd. ex Roem. & Schult.) Moq. 4338

Iresine heterophylla Standl. 3952

**Salsola tragus* L. 4535

ANACARDIACEAE

Rhus aromatica Aiton var. *trilobata* (Nutt.) A. Gray. 4243

Rhus virens Lindh. ex A. Gray var. *choriophylla* (Wooton & Standl.) L. D. Benson. 4549

Toxicodendron radicans (L.) Kuntze. 4244

APIACEAE

Bowlesia incana Ruiz & Pav. 4052

Daucus pusillus Michx. 4099, 5359

Lomatium nevadense (S. Watson) J. M. Coult. & Rose var. *parishii* (J. M. Coult. & Rose) Jeps. 4065

Spermolepis lateriflora G. L. Nesom. 4108, 5354

Yabea microcarpa (Hook. & Arn.) Koso-Pol. 4075, 5355

APOCYNACEAE

Apocynum cannabinum L. 4241

Asclepias asperula (Decne.) Woodson. 4119

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Asclepias linaria Cav. 4125
Asclepias nummularia Torr. 4341
Asclepias nyctaginifolia A. Gray. 4803
Funastrum crispum (Benth.) Schltr. 4830, 5189
Funastrum heterophyllum (Engelm. ex Torr.) Standl. 5104
Gonolobus arizonicus (A. Gray) Woodson. 4123
Haplophyton cimicidum A. DC. 4302
Mandevilla brachysiphon (Torr.) Pichon. 4418
Matelea tristiflora (Standl.) Woodson. 4798

ARALIACEAE

Aralia humilis Cav. 4601

ASTERACEAE

Acourtia nana (A. Gray) Reveal & R. M. King. 5113
Acourtia thurberi (A. Gray) Reveal & R. M. King. 4291
Adenophyllum porophyllum (Cav.) Hemsl. 4567
Aldama cordifolia (A. Gray) E. E. Schill. & Panero. 4603, 4642
Ambrosia confertiflora DC. 4589
Ambrosia monogyra (Torr. & A. Gray) Strother & B. G. Baldwin. 4383
Artemisia dracunculus L. 4980
Artemisia ludoviciana Nutt. subsp. *ludoviciana*. 4628
Artemisia ludoviciana subsp. *mexicana* (Willd. ex Spreng.) D. D. Keck. 3945
Baccharis pteronioides DC. 4282
Baccharis salicifolia (Ruiz & Pav.) Pers. 3941
Baccharis sarothroides A. Gray. 3942
Baccharis thesioides Kunth. 3943, 5016
Bahia absinthifolia Benth. 4213
Baileya multiradiata Harv. & A. Gray. 4232, 4889
Barkleyanthus salicifolius (Kunth) H. Rob. & Brettell. 4090
Bebbia juncea (Benth.) Greene var. *aspera* Greene. 4898
Bidens aurea (Aiton) Sherff. 4629
Bidens leptcephala Sherff. 4499
Brickellia amplexicaulis B. L. Rob. 4622
Brickellia baccharidea A. Gray. 4654
Brickellia californica (Torr. & A. Gray) A. Gray. 4602
Brickellia coulteri A. Gray var. *brachiata* (A. Gray) B. L. Turner. 3947
Brickellia floribunda A. Gray. 4625
Brickellia venosa (Wooton & Standl.) B. L. Rob. 4505, 4969
Calycoseris wrightii A. Gray. 4049
Carminatia tenuiflora DC. 4573
Carphochaete bigelovii A. Gray. 5070
Chaetopappa ericoides (Torr.) G. L. Nesom. 4155
Cirsium neomexicanum A. Gray. 4177
Coreocarpus arizonicus (A. Gray) Blake. 4643
Diaperia verna (Raf.) Morefield. 4114
Encelia farinosa A. Gray ex Torr. 4096
Ericameria laricifolia (A. Gray) Shinnars. 3940
Erigeron arisoli G. L. Nesom. 4820
Erigeron canadensis L. [*Conyza canadensis* (L.) Cronquist]. 4402
Erigeron divergens Torr. & A. Gray. 4138
Erigeron incomptus A. Gray. 3970
Erigeron neomexicanus A. Gray. 4512
Erigeron sceptrifer G. L. Nesom. 4364
Erigeron tracyi Greene. 4214
Eriophyllum lanosum (A. Gray) A. Gray. 4201

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Fleischmannia sonora (A. Gray) King & H. E. Rob. 4978
Gaillardia pinnatifida Torr. 4839
Gamochaeta stagnalis (I. M. Johnst.) Anderb. 4143, 5092
Guardiola platyphylla A. Gray. 4267
Gutierrezia microcephala (DC.) A. Gray. 4528
Helenium thurberi A. Gray. 4261, 5114
Helioomeris longifolia (B. L. Rob. & Greenm.) Cockerell var. *annua* (M. E. Jones) Yates. 3944
Helioomeris multiflora Nutt. 5019
Heterosperma pinnatum Cav. 4579
Heterotheca subaxillaris (Lam.) Britton & Rusby subsp. *latifolia* (Buckley) Semple. 4531
Hymenothrix wislizeni A. Gray. 4905
Hymenothrix wrightii A. Gray. 3963
Isocoma tenuisecta Greene. 4537
**Lactuca serriola* L. 4314
Laennecia coulteri (A. Gray) G. L. Nesom. 4488
Laennecia sophiifolia (Kunth) G. L. Nesom. 4487
Lasiantha podocephala (A. Gray) K. M. Becker. 4520
Logfia filaginoides (Hook. & Arn.) Morefield. 4112
Machaeranthera tagetina Greene. 4426
Malacothrix fendleri A. Gray. 4130
Malacothrix stebbinsii W. S. Davis & P. H. Raven. 4141
Melampodium longicorne A. Gray. 4496
Melampodium strigosum Stuessy. 4523
Parthenice mollis A. Gray. 4399
Pectis cylindrica (Fernald) Rydb. 4827
Pectis filipes Harvey & A. Gray var. *subnuda* Fernald. 4494
Pectis longipes A. Gray. 4134
Pectis prostrata Cav. 4404
Porophyllum ruderale (Jacq.) Cass. var. *macrocephalum* (DC.) Cronquist. 4413
Pseudognaphalium canescens (DC.) Anderb. 4534
Pseudognaphalium leucocephalum (A. Gray) Anderb. 4518
**Pseudognaphalium luteoalbum* (L.) Hilliard & B. L. Burt. 4210
Pseudognaphalium stramineum (Kunth) W. A. Weber. 4148
Rafinesquia californica Nutt. 4235
Rafinesquia neomexicana A. Gray. 4116
Sanvitalia abertii A. Gray. 4541
Schkuhria pinnata (Lam.) Kuntze ex Thell. 4498
Senecio flaccidus Less. var. *flaccidus*. 4283
Solidago velutina DC. 4656
**Sonchus asper* (L.) Hill. 4150
**Sonchus oleraceus* L. 4193
Stephanomeria pauciflora (Torr.) A. Nelson. 4538
Stylocline micropoides A. Gray. 4196
Symphyotrichum subulatum (Michx.) G. L. Nesom var. *parviflorum* (Nees) S.D. Sundb. 4386
Thelesperma megapotamicum (Spreng.) Kuntze. 4416
Thymophylla concinna (A. Gray) Strother. 4200
Thymophylla pentachaeta (DC.) Small var. *belenidium* (DC.) Strother. 4939
Tithonia thurberi A. Gray. 4526
Trixis californica Kellogg. 4258
Uropappus lindleyi (DC.) Nutt. 4139
Viguiera dentata (Cav.) Spreng. var. *lancifolia* S. F. Blake. 3954
Xanthisma gracile (Nutt.) D. R. Morgan & R. L. Hartm. 4519
Xanthium strumarium L. 4373
Zinnia acerosa (DC.) A. Gray. 4744

BIGNONIACEAE

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Chilopsis linearis (Cav.) Sweet subsp. *arcuata* (Fosberg) Henrickson. 4259
Tecoma stans (L.) Juss. ex Kunth var. *angustata* Rehder. 4458, 5191

BORAGINACEAE (see also HELIOTROPIACEAE, HYDROPHYLLACEAE, and NAMACEAE)

Cryptantha barbigera (A. Gray) Greene. 4082
Cryptantha pterocarya (Torr.) Greene. 4106
Eremocarya micrantha (Torr.) Greene. 4085, 5116
Johnstonella pusilla (Torr. & A. Gray) Hasenstab & M.G. Simpson. 4199
Pectocarya heterocarpa (I. M. Johnst.) I. M. Johnst. 4158
Pectocarya recurvata I. M. Johnst. 4109
Plagiobothrys arizonicus (A. Gray) Greene ex A. Gray. 4136

BRASSICACEAE

Boechera perennans (S. Watson) W. A. Weber. 4053
Descurainia pinnata (Walter) Britton. 4046, 5099, 5356
Dryopetalon runcinatum A. Gray. 4073
Hesperidanthus linearifolius (A. Gray) Rydb. 3959
Lepidium oblongum Small. 4070, 5360
Lepidium virginicum L. 4071, 4844, 5001
**Nasturtium officinale* Aiton. 5069
Pennellia micrantha (A. Gray) Nieuwl. 4550
**Sisymbrium irio* L. 4047
Streptanthus carinatus C. Wright ex A. Gray subsp. *arizonicus* (S. Watson) Kruckeb., Rodman & Worth. 4098
Thysanocarpus curvipes Hook. 4013

CACTACEAE

Carnegiea gigantea (Engelm.) Britton & Rose. 4317
Coryphantha vivipara (Nutt.) Britton & Rose var. *bisbeeana* (Orcutt) L. D. Benson. 4319
Cylindropuntia spinosior (Engelm.) Knuth. 4293
Echinocereus rigidissimus (Engelm.) Engelm. ex Haage. 4320
Echinocereus santaritensis W. Blum & Rutow. 5077 (SEINet), 5086 (SEINet)
Ferocactus wislizeni (Engelm.) Britton & Rose. 4367, 5064
Mammillaria grahamii Engelm. 5075 (SEINet)
Mammillaria macdougalii Rose. 4159
Mammillaria wrightii Engelm. var. *wilcoxii* (Toumey ex K. Schum.) W. T. Marshall. 4747
Opuntia engelmannii Salm-Dyck ex Engelm. var. *engelmannii*. 4316
Opuntia laevis J. M. Coult. 4312
Opuntia santa-rita (Griffiths & Hare) Rose. 4290, 4292

CAMPANULACEAE

Triodanis biflora (Ruiz & Pav.) Greene. 4202
Triodanis holzingeri McVaugh. 4246

CANNABACEAE

Celtis pallida Torr. 3979
Celtis reticulata Torr. 3980

CARYOPHYLLACEAE

Cerastium texanum Britton. 4063
Drymaria molluginea (Ser.) Didr. 4813
Silene antirrhina L. 4078, 5352

CLEOMACEAE

Polanisia dodecandra (L.) DC. subsp. *trachysperma* (Torr. & A. Gray) Iltis. 5188

COCHLOSPERMACEAE

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Amoreuxia palmatifida DC. 4396

CONVOLVULACEAE

Convolvulus equitans Benth. 4340

Cuscuta erosa Yunck. 4834, 4970

Evolvulus alsinoides (L.) L. 4459

Evolvulus arizonicus A. Gray. 4318, 5176

Evolvulus sericeus Sw. 4321

Ipomoea barbatisepala A. Gray. 4375

Ipomoea capillacea (Kunth) G. Don. 4508

Ipomoea costellata Torr. 4414

Ipomoea cristulata Hallier f. 4525

Ipomoea hederacea Jacq. 4578

Ipomoea ternifolia Cav. var. *leptotoma* (Torr.) J. A. McDonald. 4840

Ipomoea thurberi A. Gray. 4836

CUCURBITACEAE

Apodanthera undulata A. Gray. 4465

Cucurbita digitata A. Gray. 4821

Echinopepon wrightii (A. Gray) S. Watson. 4464

Sicyosperma gracile A. Gray. 4522

EUPHORBIACEAE

Acalypha neomexicana Müll. Arg. 3966

Acalypha ostryifolia Riddell ex J. M. Coult. 4783, 4824

Cnidoscolus angustidens Torr. 4309

Euphorbia albomarginata Torr. & A. Gray. 4203

Euphorbia arizonica Engelm. 4105, 4424

Euphorbia capitellata Engelm. 4897

Euphorbia exstipulata Engelm. 4809

Euphorbia heterophylla L. 4447, 4564

Euphorbia hirta L. 3951

Euphorbia hyssopifolia L. 3953

Euphorbia indivisa (Engelm.) Tidestr. 4403

Euphorbia pediculifera Engelm. var. *pediculifera*. 4247

Euphorbia revoluta Engelm. 4509, 4825

Euphorbia serpillifolia Pers. 4943

Euphorbia setiloba Engelm. 4873

Euphorbia stictospora Engelm. 4808

Jatropha macrorhiza Benth. 4332

Manihot angustiloba (Torr.) Müll. Arg. 4427, 4805

Tragia laciniata (Torrey) Müll. Arg. 4644

Tragia nepetifolia Cav. 4189, 4586

FABACEAE

Acaciella angustissima (Mill.) Britton & Rose. 4306

Acmispon brachycarpus (Benth.) D. D. Sokoloff. 4132, 5106

Acmispon greenei (Wooton & Standl.) Brouillet. 4135, 5081

Acmispon oroboides (Kunth) Brouillet. 4206

Amorpha fruticosa L. 4374

Astragalus arizonicus A. Gray. 4197

Astragalus nothoxys A. Gray. 4074

Astragalus nuttallianus DC. 4079

Calliandra eriophylla Benth. 4118

Calliandra humilis Benth. var. *humilis*. 4582

Calliandra humilis var. *reticulata* (A. Gray) L. D. Benson. 4517

- Chamaecrista nictitans* (L.) Moench var. *leptadenia* (Greenm.) Gandhi & S. L. Hatch. 3958, 4975
Cologania angustifolia Kunth. 5017
Coursetia caribaea (Jacq.) Lavin var. *sericea* (A. Gray) Lavin. 4268
Crotalaria pumila Ortega. 4527
Dalea albiflora A. Gray. 4645
Dalea formosa Torr. 4144, 4195
Dalea grayi (Vail) L. L. Williams. 4315
Dalea nana Torr. ex A. Gray. 4152, 4937, 4971
Dalea pogonathera A. Gray. 4151
Dalea pulchra Gentry. 4110, 5079
Dalea versicolor Zucc. var. *sessilis* (A. Gray) Barneby. 4068
Dalea wrightii A. Gray. 4902, 4972
Desmanthus cooleyi (Eaton) Branner & Coville. 4408
Desmodium batocaulon A. Gray. 4872
Desmodium cinerascens A. Gray. 4869
Desmodium neomexicanum A. Gray. 4584, 4933, 4997
Desmodium psilocarpum A. Gray. 4817
Desmodium rosei B. G. Schub. 4547
Erythrina flabelliformis Kearney. 4294
Eysenhardtia orthocarpa (A. Gray) S. Watson. 4270, 5192
Galactia wrightii A. Gray. 4397
Lupinus concinnus J. G. Agardh. 4086
Lupinus sparsiflorus Benth. 4174
Macroptilium gibbosifolium (Ortega) A. Delgado. 4497
Marina calycosa (A. Gray) Barneby. 4153
Mariosousa millefolia (S. Watson) Seigler & Ebinger. 4303, 4423
Mimosa aculeaticarpa Ortega var. *biuncifera* (Benth.) Barneby. 4266
Mimosa dysocarpa Benth. 4305
Mimosa grahamii A. Gray. 4288
Nissolia schottii (Torr.) A. Gray. 4425, 4795
Parkinsonia florida (Benth. ex A. Gray) S. Watson. 4899
Phaseolus acutifolius A. Gray var. *latifolius* G. F. Freeman. 4887
Phaseolus acutifolius var. *temuifolius* A. Gray. 3978
Prosopis velutina Wooton [*Neltuma velutina* (Wooton) Britton & Rose]. 4260
Rhynchosia edulis Griseb. 4871
Rhynchosia minima (L.) DC. 3972
Rhynchosia senna Gillies ex Hook. & Arn. var. *texana* (Torr. & A. Gray) M. C. Johnst. 4289
Senegalia greggii (A. Gray) Britton & Rose [*Acacia greggii* A. Gray]. 4263
Senna hirsuta (L.) H. S. Irwin & Barneby var. *glaberrima* (M. E. Jones) H. S. Irwin & Barneby. 4384
Sphinctospermum constrictum (S. Watson) Rose. 4799, 4903
Tephrosia leiocarpa A. Gray. 4419
Tephrosia tenella A. Gray. 4790, 4979
Vicia ludoviciana Nutt. ex Torr. & A. Gray. 4080, 5102

FAGACEAE

- Quercus emoryi* Torr. 4343
Quercus oblongifolia Torr. 4536

FOUQUIERIACEAE

- Fouquieria splendens* Engelm. 4308

GARRYACEAE

- Garrya wrightii* Torr. 4460

GENTIANACEAE

- Zeltnera arizonica* (A. Gray) G. Mans. 4278

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Zeltnera nudicaulis (Engelm.) G. Mans. 4279, 5100

GERANIACEAE

**Erodium cicutarium* (L.) L'Hér.. 4077

Erodium texanum A. Gray. 4156

HELIOTROPIACEAE

Euploca fruticosa (L.) J. I. M. Melo & Semir. 4516, 4838

Heliotropium hartwegianum (Steud.) Halse & Feuillet [*Tournefortia hartwegiana* Steud.]. 4845, 4846, 5066, 5067

HYDRANGEACEAE

Fendlera rupicola A. Gray. 4128, 5084

Philadelphus microphyllus A. Gray. 4463

HYDROPHYLLACEAE

Eucrypta micrantha (Torr.) A. Heller. 4072

Phacelia affinis A. Gray. 4093

Phacelia arizonica A. Gray. 4055

Phacelia bombycina Wootton & Standl. 4173

Phacelia caerulea Greene. 4087, 5358

Phacelia distans Benth. 4113, 5357

Phacelia sonoitensis S. P. McLaughlin. 4083, 4191, 5363

JUGLANDACEAE

Juglans major (Torr.) A. Heller. 4281

KRAMERIACEAE

Krameria erecta Willd. 4212

LAMIACEAE

Clerodendrum coulteri (A. Gray) Govaerts [*Tetraclea coulteri* A. Gray]. 4874

Hedeoma dentata Torr. 4652

**Lamium amplexicaule* L. 4091

Salvia parryi A. Gray. 4801

Salvia subincisa Benth. 4380

Stachys coccinea Ortega. 4081, 5085

Trichostema arizonicum A. Gray. 4930

LINACEAE

Linum puberulum (Engelm.) A. Heller. 4411, 4565

LOASACEAE

Mentzelia albicaulis (Douglas) Douglas ex Torr. & A. Gray. 4054, 5362

Mentzelia aspera L. 4816

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LYTHRACEAE

Ammannia auriculata Willd. 4904, 4942, 4999, 5031

Cuphea wrightii A. Gray. 4941

Rotala ramosior (L.) Koehne. 5002

MALPIGHIACEAE

Aspicarpa hirtella Rich. 4818

Cottisia gracilis (A. Gray) W. R. Anderson & C. Davis. 3946

MALVACEAE

Abutilon abutiloides (Jacq.) Garcke ex Hochr. 4901
Abutilon incanum (Link) Sweet. 3961, 4886
Abutilon mollicomum (Willd.) Sweet. 3968
Abutilon reventum S. Watson. 4313
Anoda abutiloides A. Gray. 3969
Anoda cristata (L.) Schltdl. 4548
Ayenia filiformis S. Watson. 3960
Gossypium thurberi Tod. 4307
Herissantia crispa (L.) Brizicky. 3948
Hibiscus biseptus S. Watson. 4462
Rhynchosida physocalyx (A. Gray) Fryxell. 4175
Sida abutilifolia Mill. 4204
Sida glabra Mill. 4976
Sida spinosa L. 4513
Sphaeralcea laxa Wooton & Standl. 3962, 5048

MARTYNIACEAE

Proboscidea parviflora (Wooton) Wooton & Standl. 4269

MENISPERMACEAE

Cocculus diversifolius DC. 4124, 4702

MOLLUGINACEAE

Glinus radiatus (Ruiz & Pav.) Rohrb. 4361
Mollugo verticillata L. 4353

MONTIACEAE

Calandrinia ciliata (Ruiz & Pav.) DC. var. *menziesii* (Hook.) Macbr. 4057
Cistanthe monandra (Nutt.) Hershk. 4060, 5115
Phemeranthus aurantiacus (Engelm.) Kiger. 4394
Phemeranthus parviflorus (Nutt.) Kiger. 4409

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Nama hispida A. Gray. 4211

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Allionia incarnata L. 4183
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Epilobium canum (Greene) P. H. Raven subsp. *latifolium* (Hook.) P. H. Raven. 3974

Eremothera chamaenerioides (A. Gray) W. L. Wagner & Hoch 4100

Eulobus californicus Nutt. ex Torr. & A. Gray. 4094

Oenothera primiveris A. Gray. 4050

Oenothera rosea L'Hér. ex Aiton. 4275

OROBANCHACEAE

Brachystigma wrightii (A. Gray) Pennell. 4542

Castilleja minor (A. Gray) A. Gray var. *minor*. 5105

Castilleja tenuiflora Benth. 4209

OXALIDACEAE

Oxalis albicans L. 4406, 4746

Oxalis latifolia Kunth. 4389

PAPAVERACEAE

Argemone pleiacantha Greene. 4240

Corydalis aurea Willd. subsp. *occidentalis* (A. Gray) G. B. Ownbey. 4045

Eschscholzia californica Cham. subsp. *mexicana* (Greene) C. Clark. 4067

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Rivina humilis L. 4370

PHRYMACEAE

Erythranthe floribunda (Lindl.) G. L. Nesom. 5097

Erythranthe guttata (DC.) G. L. Nesom. 4126, 5091

Erythranthe rubella (A. Gray) N. S. Fraga. 4092

PHYLLANTHACEAE

Phyllanthus polygonoides Nutt. ex Spreng. 4789

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Mecardonia procumbens (Mill.) Small. 4137

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Penstemon barbatus (Cav.) Roth. 5382

Penstemon parryi A. Gray. 4117

Plantago patagonica Jacq. 4111

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Sairocarpus nuttallianus (Benth. ex A. DC.) D. A. Sutton. 4102

Schistophragma intermedium (A. Gray) Pennell. 4515

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Veronica peregrina L. subsp. *xalapensis* (Kunth) Pennell. 4076, 5089

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Hebecarpa obscura (Benth.) J. R. Abbott [*Polygala obscura* Benth.]. 4334, 5175

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Eriogonum abertianum Torr. 4140

Eriogonum polycladon Benth. 4379

Eriogonum wrightii Torr. ex Benth. 3967

**Polygonum aviculare* L. 4285

PORTULACACEAE

Portulaca oleracea L. 4495

Portulaca suffrutescens Engelm. 4398, 4810

Portulaca umbraticola Kunth. 4405

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Anagallis minima (L.) E. H. L. Krause. 5108

Androsace occidentalis Pursh. 4048

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Clematis drummondii Torr. & A. Gray. 4335

Delphinium scaposum Greene. 4238

Myosurus cupulatus S. Watson. 5090, 5361

Myosurus minimus L. 4145, 5074

Thalictrum fendleri Engelm. ex A. Gray. 4540

RHAMNACEAE

Condalia correllii M. C. Johnst. 4342

Sarcomphalus obtusifolius (Hook. ex Torr. & A. Gray) Hauenschild [*Ziziphus obtusifolia* (Hook. ex Torr. & A. Gray) A. Gray]. 4107

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Galium aparine L. 4157

Galium microphyllum A. Gray. 4239

Galium wrightii A. Gray. 4577

Hexasepalum teres (Walter) J. H. Kirkbr. [*Diodia teres* Walter]. 4502

Houstonia prostrata Brandegee [*Hedyotis vegrandis* W. H. Lewis]. 4788

Mitracarpus hirtus (L.) DC. 4811

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Ptelea trifoliata L. 4828

SALICACEAE

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Salix gooddingii Ball. 4245, 5109

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Sapindus saponaria L. 4304

SAXIFRAGACEAE

Heuchera sanguinea Engelm. 4604

SCROPHULARIACEAE

Limosella acaulis Sessé & Moc. 4287

SOLANACEAE

Calibrachoa parviflora (Juss.) D'Arcy. 4331, 5093

Datura quercifolia Kunth. 4870

Datura wrightii Regel. 4392

Lycium berlandieri Dunal. 4796

Nicotiana obtusifolia M. Martens & Galeotti. 4127

Physalis pubescens L. 4511

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Solanum adscendens Sendtn. 4524

Solanum elaeagnifolium Cav. 4745

Solanum lumholtzianum Bartlett. 4807

Solanum nigrescens M. Martens & Galeotti. 4265

TALINACEAE

Talinum paniculatum (Jacq.) Gaertn. 4410

URTICACEAE

Parietaria pensylvanica Muhl. ex Willd. 4146

VERBENACEAE

Aloysia wrightii (A. Gray ex Torr.) A. Heller. 4451

Bouchea prismatica (L.) Kuntze. 4802

Verbena xylopoda (L. M. Perry) G. L. Nesom. 4179, 5353

VIBURNACEAE

Sambucus cerulea Raf. 4280

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Phoradendron californicum Nutt. 4363

Phoradendron capitellatum Torr. ex Trel. 4242

Phoradendron leucarpum (Raf.) Reveal & M. C. Johnst. 4345, 4655

VITACEAE

Vitis arizonica Engelm. 4867, 5189

ZYGOPHYLLACEAE

Kallstroemia californica (S. Watson) Vail. 4787

Kallstroemia grandiflora Torr. ex A. Gray. 4390

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AMARYLLIDACEAE

Allium rhizomatum Wooton & Standl. 4500

Habranthus longifolius (Hemsl.) Flagg, G. Lom. Sm. & Meerow [*Zephyranthes longifolia* Hemsl.]. 4786

Nothoscordum bivalve (L.) Britton. 4532

ARACEAE

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Lemna gibba L. 3976, 4712

Lemna minuta Kunth. 4707

ASPARAGACEAE

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Agave schottii Engelm. var. *schottii*. 4295, 4461

Dasyllirion wheeleri S. Watson. 4368

Dipterostemon capitatus (Benth.) Rydb. subsp. *pauciflorus* (Torr.) R. E. Preston. 4061

Echeandia flavescens (Schult. & Schult. f.) Cruden. 4572

Milla biflora Cav. 4506

Nolina microcarpa S. Watson. 4264, 5174

Yucca baccata Torr. var. *brevifolia* L. D. Benson & Darrow. 5076

Yucca elata (Engelm.) Engelm. 5080

Yucca cf. *schottii* [*Y. schottii* Engelm., *nomen illegitimum*. *Y. x schottii* (Engelm.) pro. sp. Lenz & Hanson. Nomenclature of this yucca is unresolved; see Lenz & Hanson 2000, 2001; Hess & Robbins 2002]. 4333

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Commelina dianthifolia Delile. 4823

Commelina erecta L. 4446

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Cyperus dipsaceus Liebm. 4575, 4936

Cyperus esculentus L. 4782, 4982

Cyperus flavicomus Michx. 4569, 4895, 4896

Cyperus hemidrummondii Goetgh. [*Lipocarpa drummondii* (Nees) G. C. Tucker]. 4985, 4986, 4998

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Cyperus odoratus L. 3975, 4385, 4466

Cyperus pallidicolor (Kük.) G. C. Tucker. 4546, 4588

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Cyperus squarrosus L. 4570, 4983

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Eleocharis montevidensis Kunth. 4215, 5107

Eleocharis parishii Britton. 4277, 4365

Fimbristylis annua (All.) Roem. & Schult. 4514, 4571

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Juncus interior Wiegand. 4273

Juncus marginatus Rostk. 4366

Juncus saximontanus A. Nelson. 4248, 4274

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Calochortus kennedyi Porter. 4131

NAJADACEAE

Najas guadalupensis (Spreng.) Magnus. 5006

POACEAE

Alopecurus carolinianus Walter. 5072, 5088

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Aristida schiedeana Trin. & Rupr. var. *orcuttiana* (Vasey) Allred & Valdés-Reyna. 4583
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Aristida ternipes var. *ternipes*. 4382
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Bouteloua barbata var. *rothrockii* (Vasey) Gould. 4590, 4835
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**Echinochloa colona* (L.) Link. 4284
**Echinochloa crus-galli* (L.) P. Beauv. 4354, 4521
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Eriochloa acuminata (J. Presl) Kunth. 4453
**Hackelochloa granularis* (L.) Kuntze. 4566, 4931
Heteropogon contortus (L.) P. Beauv. ex Roem. & Schult. 4493
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Paspalum setaceum Michx. 4814
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Piptochaetium fimbriatum (Kunth) Hitchc. 5003
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**Polypogon monspeliensis* (L.) Desf. 4178, 4710
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Setaria grisebachii Fourn. 4580
Setaria macrostachya Kunth. 3973, 4452
Sphenopholis obtusata (Michx.) Scribn. 4330
Sporobolus cryptandrus (Torr.) A. Gray. 4630
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Vulpia octoflora (Walter) Rydb. 4058
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POTAMOGETONACEAE

Potamogeton pusillus L. 4286

TYPHACEAE

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Figure 8. Coal Mine Canyon, 6 Aug 2021.

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PLANTAGINACEAE PLANTAIN FAMILY

FAMILY DESCRIPTION, KEY TO GENERA, AND *PENSTEMON* SCHMIDEL

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Herbs, subshrubs, or shrubs, annual or perennial, sometimes biennial. STEMS prostrate, decumbent, ascending, or erect, sometimes arching, creeping, sprawling, spreading, pendent, climbing or reclining, sometimes greatly reduced. LEAVES deciduous or persistent, basal, basal and cauline, or cauline, opposite, subopposite, alternate, helical, or whorled, sometimes opposite proximally, alternate distally, simple; stipules absent; petiole present or absent; blade fleshy or not, leathery or not, margins entire to subentire, toothed, or lobed. INFLORESCENCE axillary or terminal, spikes, racemes, cymes, corymbs, thyrses, whorls, panicles, or flowers solitary. FLOWERS bisexual, rarely unisexual (*Callitriche*, *Hippuris*), perianth and androecium hypogynous (epigynous in *Hippuris*); sepals (2–)4 or 5, basally or proximally connate, sometime distinct, rarely as a minute rim on the summit of the ovary (*Hippuris*) or lacking (*Callitriche*), the calyx radially or bilaterally symmetric; petals lacking (*Callitriche*, *Hippuris*) or (3–)4–5, connate, the corolla radially or bilaterally symmetric, bilabiate or regular, unilateral (*Synthyris*), rotate to salverform, cylindric, tubular, funnelform, urceolate, ellipsoid, globular, ovoid, or ligulate; stamens (1–)2–5, adnate to corolla or free, dydynamous or equal; staminodes lacking or 1(–3); pistil 1, 2-carpellate (1 carpel in *Hippuris*); ovary superior (inferior in *Hippuris*), placentation usually axile; styles 1(–2). FRUITS usually capsules, schizocarps (*Callitriche*), or drupes (*Hippuris*), dehiscence loculicidal, septicidal, or poricidal, circumscissile (*Plantago*). SEEDS 1–300, white, tan, brown, yellow, gray, black, maroon, or red, ovoid to ellipsoid, cylindric, globular, oblong, conic, disciform, patelliform, or angled; embryo straight, rarely curved; endosperm present.—ca. 100 genera and ca. 1900 species worldwide (25 genera and ca. 103 species in AZ: nearly worldwide, apparently absent in much of tropical S. Amer., arid n Africa and n Australia (Freeman *et al* 2019).

Kearney and Peebles (1960) considered Plantaginaceae to include only the genus *Plantago*, which is how Huisinga and Ayers (1999) treated the family in AZ. Molecular work (Olmstead and Reeves 1995; Albach et al. 2005; Oxelman et al. 2005) supports a broadly expanded Plantaginaceae, with *Plantago* and 22 genera from the traditional Scrophulariaceae, *Hippuris* from Haloragaceae, and *Callitriche* from Callitrichaceae. This last family was previously treated separately for the Vascular Plants of Arizona by Ricketson (1995). Sixteen of the 25 genera in AZ include just one species each. For AZ, *Penstemon*, the largest genus with 50 species and 3 named hybrids, accounts for more than half the family. *Plantago* is the next largest genus with 12 species, while there are 9 species of AZ *Veronica*.

KEY TO THE ARIZONA GENERA OF PLANTAGINACEAE

1. Corolla lobes 0; stamens 1; sepals 0 or appearing as minute rims at summits of ovaries; wetlands.
 2. Leaves opposite; fruits schizocarps; ovaries superior; styles 2..... *Callitriche* (see Ricketson 1995)
 - 2' Leaves whorled; fruits drupes; ovaries inferior; styles 1..... *Hippuris vulgaris*
- 1' Corolla lobes 3–5; stamens 2–4(–5); sepals 2–5; wetlands or not.
 3. Corolla tubes spurred, ±saccate, or gibbous, or with rounded sacs at bases of median lobes.
 4. Corolla tube bases ±saccate or gibbous adaxially, sometimes obscurely so *Collinsia*
 - 4' Corolla tube bases spurred or gibbous abaxially.
 5. Corolla tube bases spurred.
 6. Corolla abaxial lips as long as or slightly longer than adaxials; filaments usually hairy proximally; capsules 9–12 mm long; plants exotic *Linaria*
 - 6' Corolla abaxial lips much longer than adaxials; filaments glabrous; capsules 2–4.8 mm long; plants native. *Nuttallanthus texanus*
 - 5' Corolla tube bases gibbous.
 7. Inflorescences terminal; plants exotic. native..... *Antirrhinum majus*
 - 7' Inflorescences axillary; plants native.
 8. Corolla throat not closed; stamens 2; staminode 2–3..... *Mohavea*
 - 8' Corolla throat closed; stamens 4; staminodes 0–1.
 9. Fruit locules unequal in size; seeds 0.5–1 mm long. *Sairocarpus*
 - 9' Fruit locules equal in size; seeds 1–2.5 mm long.
 10. Stems erect, ascending, or sprawling, glabrous or hairy, not glandular; leaves lanceolate to ovate, 2–15 mm wide; bracts absent; pedicels twining, not recurved in fruit; seeds 1 mm long; pollen sacs 2. *Neogaerrhinum filipes*
 - 10' Stems erect, glandular hairy; leaves ovate to broadly ovate, 20–25 mm wide; bracts present; pedicels not twining, recurved in fruit; seeds 1.5–2.5 mm long; pollen sac..... *Pseudorontium cyathiferum*
 - 3' Corolla tubes not spurred, gibbous or saccate.
 11. Shrubs or subshrubs.
 12. Stamen filament bases eglandular hairy; nectaries hypogynous discs *Keckiella antirrhinoides* var. *microphylla*
 - 12' Stamen filament bases glabrous or glandular puberulent, rarely pubescent proximally; nectaries epistaminal..... *Penstemon* (in part)
 - 11' Herbs.
 13. Fruits circumscissile; leaves basal only, rarely cauline; corolla lobes 4; stamens free *Plantago* (see Huisinga and Ayers 1999)
 - 13' Fruits not circumscissile, rarely drupelike; leaves basal and cauline or cauline only, rarely basal only; corolla lobes 3–5, stamens adnate to corolla, rarely inserted on receptacle.
 14. Stamens 2–3.
 15. Ovaries 1-locular; leaves alternate, basal or basal and cauline..... *Synthyris plantaginea*
 - 15' Ovaries 2-locular; leaves opposite, sometimes alternate distally, cauline, sometimes basal and cauline.
 16. Corollas bluish to white, the lobes 4; stamens 2..... *Veronica*
 - 16' Corollas yellow to white, the lobes 5; stamens 2-4.
 17. Bracts absent; stems prostrate; corollas campanulate..... *Bacopa rotundifolia* (in part)
 - 17' Bracts present; stems ascending to erect; corollas tubular..... *Gratiola neglecta*
 - 14' Stamens 4(–5).
 18. Leaves alternate.
 19. Staminodes 0; inflorescences terminal, racemes; bracts present; exotic plants of gardens..... *Digitalis purpurea*
 - 19' Staminodes 1; inflorescences axillary, flowers solitary; bracts absent; native plants.
 20. Leaf blade margins dentate or spinulose; corollas pale yellow to yellow or ochroleucous *Mabrya acerifolia*
 - 20' Leaf blade margins entire; corollas blue to violet, pink or red.

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- 21. Annuals, taprooted; pedicels 3–9 mm long; corolla tubes 17–22 mm long; capsules 11–15 mm long; seed wings present *Epixiphium wislizeni*
- 21' Perennials, the caudex woody; pedicels 10–45 mm long; corolla tubes 13–17 mm long; capsules 7–10 mm long; seed wings absent.....
- *Maurandella antirrhiniflora*
- 18' Leaves opposite or whorled, sometimes alternate distally.
- 22. Corollas radially symmetric..... *Bacopa monnieri*
- 22' Corollas bilaterally symmetric, rarely nearly radially symmetric.
- 23. Staminodes 1.
- 24. Bracteoles ± as large as calyx lobes, nearly surrounding calyces of flowers they subtend; plants exotic *Chelone glabra*
- 24' Bracteoles smaller than calyx lobes, not surrounding calyces of flowers they subtend; plants mostly native.
- 25. Inflorescences spikes, racemes, or flowers solitary; calyces bilaterally symmetric; capsule dehiscence loculicidal. *Stemodia durantifolia* (in part)
- 25' Inflorescences cymes or thyrses; calyces radially symmetric or nearly so; capsule dehiscence septicidal..... *Penstemon* (in part)
- 23' Staminodes none.
- 26. Leaf blade margins pinnatifid to bipinnatifid; bracteoles absent.....
- *Schistophragma intermedium*
- 26' Leaf blade margins entire, crenate, dentate, or denticulate; bracteoles present.
- 27. Leaf blade margins entire; calyx with sepals distinct, outer wider than inner; plants exotic..... *Bacopa rotundifolia* (in part)
- 27' Leaf blade margins toothed; calyx with sepals basally or proximally connate, outer lobes ± as wide as inner; plants native.
- 28. Stems glabrous; petioles present..... *Mecardonia procumbens*
- 28' Stems hairy; petioles absent..... *Stemodia durantifolia* (in part)

Penstemon Schmidel Beardtongue

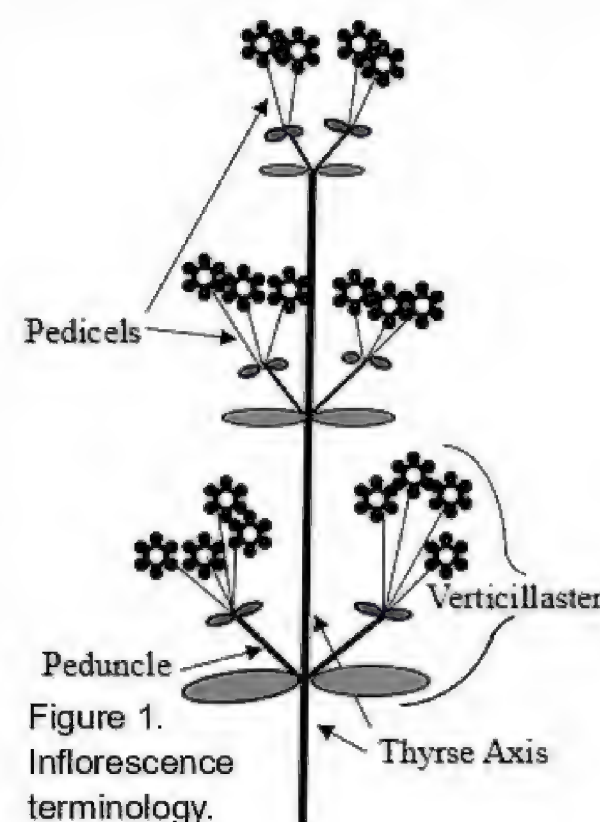
Perennial herbs, subshrubs, or shrubs, with caudices herbaceous or woody. STEMS prostrate to erect, glabrous or variously hairy, sometimes glandular. LEAVES usually deciduous, rarely persistent, basal and/or cauline, opposite, rarely whorled; petiole present or absent; blade margins entire or toothed. INFLORESCENCES terminal, thyrsoid; bracts present. PEDICELS usually present; bracteoles present. FLOWERS bisexual; calyx lobes: 5, connate proximally, radially symmetric, short-campanulate; petals 5, connate, the corolla ranging from white, pink, red, to blue, bilaterally symmetric or, rarely nearly radially symmetric, weakly to prominently bilabiate or personate, salverform, tubular, funnelform, ventricose, ampliate, or ventricose-ampliate, composed of tube, throat, and limb, with the orifice at the juncture of throat and limb, the lower lobes 3, forming the lower lip, the upper lobes 2, forming the upper lip; stamens 4, didynamous (disposed in pairs of unequal length), the lower pair adnate to corolla proximally, the upper pair adnate to the tube at various levels, the filaments glabrous or rarely glandular-puberulent proximally; anther cells paired, opposite, widely spreading, at various angles, or horseshoe shaped, either partially dehiscent from either end, or fully dehiscent, saccate, navicular, open-ended navicular, navicular-bulging, scoop-shaped, or explanate, the sides glabrous to hairy; staminode glabrous to hairy, rarely developed as a filament with functional anther cells, the tip often broadened; ovary 2-locular, placentation

axillary; stigma capitate. CAPSULES symmetric, dehiscence septicidal. SEEDS (2–)5–40(–100+), tan, brown, or black, angled and irregularly shaped.

Penstemon is a genus of 280–300 species endemic to NA, including Guat. and Mex., with ca 238 species in N. A. n of Mex. (Freeman 2019, Wolfe *et al.* 2021). There are 50 species in AZ (including 1 non-native that may be naturalizing and 3 that are likely non-native and probably not naturalizing), 7 varieties, and 3 named hybrids. Many species, especially in the w U.S., have narrow ranges (Freeman 2019). *Penstemon* is the third largest genus in N. Amer. n of Mex. after *Carex* (Cyperaceae) and *Astragalus* (Fabaceae). *Penstemon* is the fourth largest genus in AZ, after *Astragalus*, *Eriogonum*, and *Carex*. Six species are endemic to AZ. This treatment includes 13 species not included in Kearney and Peebles (1960). Nine of these were not recognized at the specific level until after 1960.

Identifying Arizona *Penstemon* species requires familiarity with the terms and plant morphology presented here. Leaf texture terms include ‘leathery’, which means having a tough hard texture, which could result from being thick, but could also result from a tough cuticle. Leaves are called glaucous when they are light bluish grey or are covered with a waxy cuticle. In the descriptions that follow, parenthetical () numbers or character states are considered uncommon. Andrea Wolfe’s web site, <https://wolfelab.asc.ohio-state.edu/database>, has wonderful closeup images that may help you to learn more about *Penstemon* flowers and confirm specimen identifications. The visual guide to identification that accompanies this treatment (starting on page 131) may be useful. Stevens *et al.* (2020) is a good source for images of whole plants, anthers, and corolla shapes.

The **inflorescence** consists of the **thyse axis**, with one-to-many nodes, each node with 1-2 branches. A **verticillaster** is the portion of the inflorescence originating at each node, whether composed of 1 or 2 branches. The stalk of each branch is the peduncle. The stalks of the individual flowers are **pedicels**. The peduncles, and the pedicels are subtended by leaflike bracts, which are progressively smaller from the base to the apex of the inflorescence (Figure 1).



Arizona *Penstemon* species corolla shapes can be tubular, salverform, funnelform, ventricose or ampliate (with intermediates), as follows:

Tubular corollas are best exemplified in AZ by *Penstemon eatonii* and *P. subulatus* (Figure 2). Tubular corollas are elongate, nearly cylindrical throughout, and sometimes have projecting lobes.

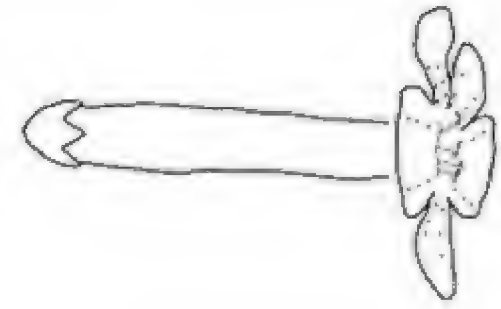
Salverform corollas are best exemplified in AZ by *Penstemon utahensis* and *P. confusus*, though they vary from truly salverform.

Figure 2.
Tubular
corolla.



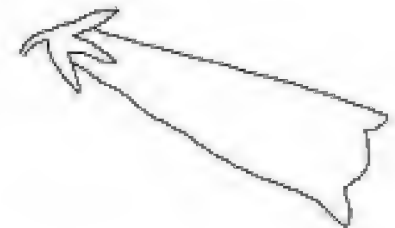
Salverform corollas have slender tubes and throats with lobes that spread at right angles to the tube (Figure 3). *Penstemon ambiguus* appears to be salverform, but is not, because the limb does not spread at right angles to the tube. Instead, it has projecting lower lobes and reflexed upper lobes (see photo guide). Other AZ species have funnellform corollas with spreading lobes, with the fused part of the corollas broader than tubular.

Figure 3.
Salverform
corolla.



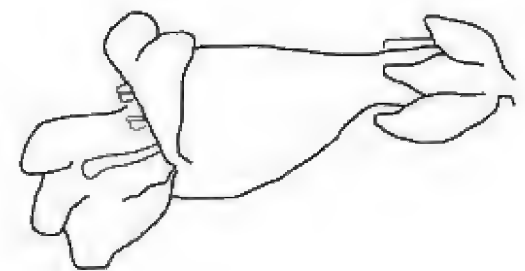
Funnelform corollas are well exemplified in our widespread species *Penstemon parryi*. Funnelform corollas have a funnel shape, with a gradually widening tube (Figure 4).

Figure 4.
Funnelform
corolla.



Most of our species have ventricose corollas that are expanded at the juncture of the tube and the throat. Ventricose corollas are expanded more on the lower side than on the upper side (Figure 5). In contrast, ampliate corollas are expanded more on the upper side than the lower side.

Figure 5.
Ventricose
corolla.



Few species have corolla shapes that are perfect examples of any of the above shapes. Also, flower color can vary, particularly when plants occur in proximity to human influences. *Penstemon barbatus* is known for its deep red flowers; *P. parryi* for its rich pink flowers, however, along roadsides, I have seen yellow *P. barbatus* flowers and both cream and red *P. parryi* flowers. Corolla length measurements in this treatment were derived from pressed plants. Rather than give overall corolla lengths, which can vary depending on how the limb was pressed, I use lengths from the base of the corolla to the orifice (tube+throat), the orifice being the area where the throat meets the limb at the base of the corolla lobes.

Anther orientation and anther cell shapes are critical for accurate identification. Anther orientation can be spreading or horseshoe-shaped. Anther cells can be proximally or distally dehiscent, navicular, open-ended navicular, navicular-bulging, scoop-shaped, explanate, or sigmoid. In addition, some species have anther cells with adornments, such as teeth on the margins of the aperture and/or papillae or vestiture on the sides of the cells, vestiture that can be sparse or dense, white or yellow, of varying lengths and density.

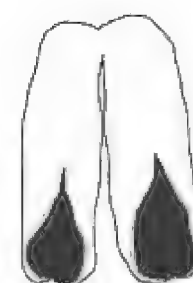
Proximally dehiscent anther cells are exemplified in *Penstemon rostriflorus*, our most common and widespread *Penstemon* species with this anther cell type (Figure 6). These anther cells and those in Figure 7 are oriented in a horseshoe shape, with the long axis of the cell parallel with the filament (what some authors call parallel), and are saccate in shape.

Figure 6.
Proximally
dehiscent
anther cells.



Distally dehiscent anther cells are exemplified in *Penstemon eatonii*, our most common and widespread *Penstemon* species with this anther cell type. This and *Penstemon ×jonesii* are our only AZ species that have anther cells that so definitely dehisce to the side (Figure 7). Not all species with anther cells that dehisce distally are so obvious. Some have just a small proximal indehiscent portion as in Figures 11 and 13.

Figure 7.
Distally
dehiscent
anther cells.



Fully dehiscent navicular-shaped anther cells are exemplified in *Penstemon linarioides*, our most common and widespread *Penstemon* species with this anther cell type (Figure 8). These anther cells resemble a peanut shell-shaped canoe with a keel that



Figure 8. Navicular anther cells, fully dehiscent.

is upturned at the ends, with the tops of the anther walls and septa flat lengthwise. Note that in navicular-shaped anther cells, the septa are about the same height as the cell walls.

Fully dehiscent open-ended navicular-shaped anther cells are exemplified in *Penstemon*

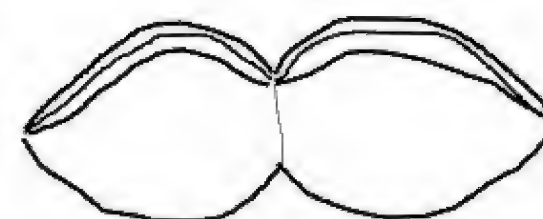
Figure 9. Open-ended
navicular anther cells,
fully dehiscent.



deaveri, *P. putus*, *P. pseudoputus*, *P. virgatus*, and *P. pachyphyllus*, (Figure 9). These anther cells have bottoms that are flat lengthwise, while the tops of the anther walls and septa are turned downwards and open at the ends. Rarely, the cell walls in these species may be spreading, mimicking an explanate anther, however the septa will be nearly the size and shape of the cell walls, making them unlike explanate anthers, which have septa that are short and squat (Figure 12).

Navicular-bulging anther cells are exemplified in *Penstemon dasyphyllus*, *P. lanceolatus* and *P. stenophyllus*, in which both abaxial and adaxial surfaces curve

Figure 10.
Navicular-bulging
anther cells, fully
dehiscent.



towards each other, giving the appearance somewhat of a bull boat (Figure 10). The anther cells in these three species are often folded or otherwise misshapen.

Scoop-shaped anther cells are exemplified in *Penstemon strictus* and *P. barbatus*. These anther cells are indehiscent proximally, while the distal portion of the openings curve down to the nearly straight bottom surface (some authors refer to these as navicular). Sometimes the portions of the cell walls adjacent to the

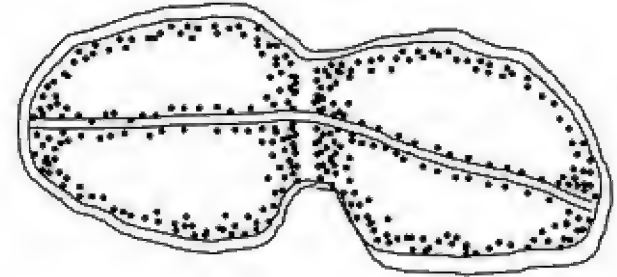


Figure 11. Scoop-shaped anther cells, indehiscent at the connective, with flat bottom and downturned tops.

aperture are slightly flared out. The septa are not shown here (Figure 11) because they are often hidden, only rising partway to the tops of the cell walls. The species that have this anther cell shape do not always have anthers spreading at 180° as shown here. More often, they spread at a lesser angle. They resemble a grain scoop.

Fully dehiscent, explanate anther cells are exemplified in *Penstemon ophianthus* and *P. subulatus* (and many others). These anther cells have walls widely spreading, laid out flat or nearly so (Figure 12). Note that the septa are shorter than one half the width of the cell walls in this anther type.

Figure 12.
Explanate
anther cells,
fully dehiscent,
top-down view.



Sigmoid anther cells are best exemplified in *Penstemon laevis*, an uncommon species in n AZ. These anther cells and apertures form S-shaped curves (Figure 13).

Figure 13. Sigmoid
anther cells, top-
down view.



KEY TO THE SPECIES OF *PENSTEMON* IN AZ

1. Anther cells not fully dehiscent.
 2. Anther cells dehiscent proximally, indehiscent distally.
 3. Corollas red, orangish red or scarlet.
 4. Corollas 11–22 mm long from base to orifice; anther cells dehiscent proximally to 1/2 of length, saccate, horseshoe-shaped; widespread..... *Penstemon rostriflorus*
 - 4' Corollas 20–27 mm long from base to orifice; anther cells dehiscent proximally to more than 1/2 of length, navicular-bulging; within AZ, restricted to se cos. *Penstemon lanceolatus* (in part)
 - 3' Corollas lavender, blue or violet.
 5. Corollas, thyrses, upper stems glandular-pubescent; staminode densely pilose, the hairs golden, to 1 mm long; wet or dry montane meadows in pine and spruce-fir forests *Penstemon oliganthus* (in part)
 - 5' Corollas, thyrses, upper stems lacking glands; staminode glabrous; pinyon-juniper woodlands *Penstemon higginsii*
 - 2' Anther cells indehiscent proximally, dehiscent distally
 6. Corollas red or reddish (scarlet).
 7. Corolla lower lobes usually reflexed; anther cells 1.5-2.2 mm long.
 8. Anther cells sparsely lanate-villous, the hairs to 1.5 mm long; leaves usually short hairy; ne AZ..... *Penstemon trichander* (in part)
 - 8' Anther cells glabrous; leaves usually glabrous, rarely short hairy; widespread *Penstemon barbatus*
 - 7' Corolla lobes projecting, projecting-spreading, or barely spreading; anther cells 1.8-2.6 mm long.
 9. Corollas tubular to tubular-funnelform, red to scarlet, colors uniform in a population, essentially unlined internally; widespread *Penstemon eatonii*
 - 9' Corollas ventricose blue to violet to reddish-magenta to pinkish, colors variable within a population, reddish violet-lined internally on the lower surface; along the UT border w of Fredonia *Penstemon ×jonesii* (in part)
 - 6' Corollas blue, purple, lavender, violet, or reddish-magenta.

10. Anther cell walls glabrous, slightly hairy near the connective, or papillate.
11. Calyx lobes glandular-pubescent; corollas 10–14 mm long from base to orifice; 1100–1600 m (3800–5400 ft); endemic to Parashant and Whitmore canyons, Mohave Co. *Penstemon distans* (in part)
- 11' Calyx lobes glabrous or sparsely pubescent (if glandular-pubescent, then corollas greater than 14 mm long from base to orifice); 1500–3500 m (4900–11,500 ft); not known from Parashant and Whitmore canyons, Mohave Co.
12. Corollas 9–18 mm long from base to orifice; anther cells spreading, scoop-shaped or open-ended navicular, not sigmoid, not misshapen.
13. Anther cell walls usually hairy, the hairs up to 2 mm long, sometimes glabrous; cells shortly indehiscent proximally; endemic to Navajo Mtn., San Juan Co., UT *Penstemon navajoa* (in part)
- 13' Anther cell walls usually glabrous, rarely papillate or hairy near the connective; cells usually fully dehiscent; in AZ, either restricted to the White and Pinaleno Mtns. or more widespread.
14. Staminode sparsely to moderately hairy; leaves green, the cauline leaves nearly as wide as basal leaves; restricted to the White and Pinaleno Mtns. *Penstemon deaveri* (in part)
- 14' Staminode glabrous; leaves usually grey green, the cauline leaves widths reduced in relation to the basal leaves; widespread *Penstemon virgatus* (in part)
- 12' Corollas 17–35 mm long from base to orifice; anther cells horseshoe-shaped to divergent, navicular-bulging or not, sometimes sigmoid, sometimes misshapen.
15. Anther cells navicular-bulging, 1.4–2.3 mm long; s and e AZ go to couplet 51.
- 15' Anther cells not navicular-bulging, 2–2.6 mm long; ne Mohave and nw Coconino cos, n AZ.
16. Stems, leaves and thyse axes glabrous; calyx lobes 3–6(–10) mm long; corollas glabrous; anther cells 2–2.2(–2.5) mm long, often a bit sigmoid; capsules 7–10 mm long; flower colors consistent within a population *Penstemon laevis*
- 16' Stems glabrous or retrorsely pubescent and glandular; leaves glabrous to pubescent; thyse axes glabrous or glandular-pubescent; calyx lobes 4–6 mm long; corollas glabrous or slightly glandular; anther cells 2.2–2.6 mm long, straight or slightly curved, but not sigmoid; capsules 10–12 mm long; flower colors often varied within a population *Penstemon ×jonesii* (in part)
- 10' Anther cell walls obviously hairy.
17. Anther cell wall hairs to 0.4 mm long *Penstemon subglaber*
- 17' Anther cell wall hairs to 2.5 mm long.
18. Calyx lobes lanceolate, 5–7.5 mm long, the apices acuminate or caudate; anther cells often sigmoid, with anther hairs to 1 mm long *Penstemon strictiformis*
- 18' Calyx lobes ovate to broadly lanceolate, 2.2–4.5 mm long, with apices not acuminate nor caudate (acuminate or mucronate in *P. navajoa*); anther cells not or only slightly sigmoid, with anther hairs 1.2–2.5 mm long (sides sometimes glabrous in *P. navajoa*).
19. Inflorescence candelabra-like due to peduncles up to 44 mm long; corolla orifice 7–14 mm wide; anther hairs up to 2.5 mm long *Penstemon comarrhenus*
- 19' Inflorescence not candelabra-like with peduncles up to 25 mm long; corolla orifice 5–12 mm wide; anther hairs up to 2 mm long.
20. Cauline leaf pairs 4–10; inflorescence more or less congested, the peduncles to 12 mm long; common in ne AZ, disturbed places elsewhere; both native and introduced; 1700–2850 m (5500–9400 ft) *Penstemon strictus*
- 20' Cauline leaf pairs 2–5; inflorescence more or less open, the peduncles to 25 mm long; endemic to Navajo Mtn.; San Juan Co., UT; native; 2200–3200 m (7200–10400 ft) *Penstemon navajoa* (in part)
- 1' Anther cells fully dehiscent; explanate or navicular.
21. Anther cells explanate, (rarely appearing as open-ended navicular in *P. utahensis* and *P. thurberi*), the septa heights less than one half the height of the cell walls.
22. Widest leaves not more than 1.5 mm wide (*P. thurberi* is reported to have leaves up to

VASCULAR PLANTS OF ARIZONA. PLANTAGINACEAE: *PENSTEMON*

4 mm wide outside of AZ).

23. Corollas scarlet, 14-25 mm long from base to orifice, glandular-pubescent externally; anther cells 0.9-1.2 mm long..... *Penstemon pinifolius*

23' Corollas white to bluish to pink, 8-14 mm long from base to orifice, glabrous externally; anther cells 0.6-0.8 mm long.

24. Calyx lobes 1.2-2 mm long; corollas seemingly salverform, the lower lobes projecting (spreading), the upper lobes reflexed (spreading), the limb 7-17 mm wide, white to pink; longer anther pair included; sand; n & e of the Mogollon Rim..... *Penstemon ambiguus*

24' Calyx lobes (1.4-)2-3(-4) mm long; corollas ampliate-funnelform, the lobes spreading, the limb 5-13 mm wide, white to bluish; longer anther pair exerted, or nearly exerted; various substrates; mostly s & w of the Mogollon Rim..... *Penstemon thurberi*

22' Widest leaves more than 1.5 mm wide.

25. Stems sprawling, herbaceous; in sand..... *Penstemon albomarginatus*

25' Stems erect or ascending or plants shrubby; substrates various.

26. Plants low shrubs; stems decumbent to ascending, 5-40 cm long; basal leaves lacking; cauline leaves up to 35 mm long, up to 28 mm wide; nw Mohave Co. *Penstemon petiolatus*

26' Plants low to tall, mostly herbaceous, stems ascending to erect, 5-210 cm long, more than the tips upright; basal leaves present; cauline leaves up to 165 mm long, up to 95 mm wide; ranges various.

27. Calyx lobes (8-)10-16 mm long; corollas 25-45 mm long from base to orifice; uncommon non-native *Penstemon cobaea*

27' Calyx lobes 1.2-10 mm long; corollas 8-35 mm long from base to orifice; native (with one exception, *P. centranthifolius*).

28. Leaf margins usually dentate, the blades lanceolate to ovate, usually thick, leathery, glaucous, 3-95 mm wide, the distal-most leaves often connate-perfoliate, sometimes tapered to sessile.

29. Staminodes with terminal 1-4 mm portion glabrous or hairy, the hairs white to yellow, to 1.5 mm long; corollas lacking hairs internally.

30. Lower portion of the staminode glabrous, the tip straight to recurved, 0.2-0.4 mm wide, glabrous or distal 1-2.5 mm hairy, the hairs yellow; washes, cliffs above watercourses, disturbed places; widespread in AZ

..... *Penstemon pseudospectabilis*

30' Lower portion of the staminode sometimes sparsely glandular pubescent, the tip straight, 0.4-0.6(-1) mm wide, glabrous or distal 1-4 mm hairy, the hairs white to yellow; restricted to cinders; San Francisco Volcanic Field

..... *Penstemon clutei*

29' Staminodes with terminal 4-10 mm portion densely bearded, the hairs to 4 mm long; corollas often hairy internally.

31. Corollas ventricose (throats gradually and narrowly expanded), the orifices 6-9 mm wide, the lower lobes 4-5 mm long and wide; staminode included to slightly exerted, distal 4-5 mm hairy, the hairs up to 2.8 mm long; mostly gravel washes; low deserts of Mohave Co.

..... *Penstemon bicolor*

31' Corollas ventricose-ampliate (throats abruptly and broadly expanded), the orifices 10-20(-24) mm wide, the lower lobes about 9 mm long, 10 mm wide; staminode clearly exerted, distal 8-10 mm hairy, the hairs to 4 mm long; various habitats, widespread

..... *Penstemon palmeri* (in part)

28' Leaf margins generally not toothed (at most repand, sinuate-dentate to dentate, or crisped in *P. breviculus*, *P. ophianthus* and *P. whippleanus*), the blades linear to ovate, oblanceolate to spatulate, leathery or not, glaucous or not, 1-45(-75) mm wide, sometimes auriculate-clasping, but not connate-perfoliate (or sometimes connate-perfoliate in *P. superbus*).

32. Calyx lobes 2-6 mm long, ovate to lanceolate; thyse axes glabrous or puberulent, if glandular, obscurely so.

33. Distal portion of staminodes hairy

34. Mid stem leaves lanceolate, to 25 (35) mm wide, thin; corollas funnelform; capsules 4–9 mm long, 2–5 mm wide; staminodes with distal 1–6 mm hairy *Penstemon parryi*
- 34' Mid stem leaves ovate to oblanceolate, to 45 mm wide, thick; corollas tubular-funnelform; capsules 10–15 mm long, 4–7 mm wide; staminodes distal 2–3 mm hairy *Penstemon superbus*
- 33' Distal portion of staminodes glabrous or at most papillate
- 35' Cauline leaves (1-)2-4(-5); corollas tubular funnelform or tubular salverform; n AZ
36. Corollas red, tubular funnelform; staminode glabrous; anther cell sutures smooth *Penstemon utahensis* (in part)
- 36' Corollas reddish-violet to purple (rarely red), tubular salverform; staminode glabrous or with distal 1–2 mm papillate, the papillae to 0.2 mm; anther cell sutures smooth or papillate *Penstemon confusus* (in part)
- 35' Cauline leaves 5-11; corollas tubular; s and w AZ.
37. Midstem leaves 10–40 mm wide; corollas 18–32 mm long from base to orifice; introduced; presently restricted to the Mt. Lemmon Highway, Santa Catalina Mtns., Pima Co. *Penstemon centranthifolius*
- 37' Midstem leaves 1–10(–15) mm wide; corollas 13–25 mm long from base to orifice; native; widespread below the Mogollon Rim *Penstemon subulatus*
- 32' Calyx lobes 4–10 mm long, lanceolate; thyse axes obviously glandular pubescent.
38. Staminodes with distal 1–3 mm hairy, the hairs to 1 mm long; subalpine forests to alpine areas *Penstemon whippleanus*
- 38' Staminodes with distal 5–9 mm hairy, the hairs to 2.4 mm long; sagebrush shrublands, pinyon-juniper and oak woodlands, and ponderosa pine forests.
39. Basal leaves 2-18 mm wide; calyx lobes equally internally and externally glandular-pubescent; corollas yellowish or whitish hairy internally; anther cells 0.6–1 mm long; staminode with distal 5–8 mm densely hairy, the hairs to 1.8 mm long; n Apache Co. *Penstemon breviculus*
- 39' Basal leaves 1-12 mm wide; calyx lobes less densely glandular-puberulent internally than externally; corollas white hairy and at least sparsely glandular-pubescent internally (sometimes obscurely so); anther cells 0.8–1.4 mm long; staminode with distal 8–9 mm moderately hairy, the hairs to 2.4 mm long; n AZ *Penstemon ophianthus*
- 21' Anther cells navicular, open-ended navicular, or navicular-bulging, the septa heights nearly one half to more than one half the width of the cell walls.
40. Plants caespitose.
41. Calyx lobes 2–3.7 mm long; anther cells 0.8–0.9 mm long; lower leaf surfaces glabrous or much less densely hairy than the upper leaf surfaces, the cauline leaf widths 1–1.5 mm; se AZ *Penstemon discolor*
- 41' Calyx lobes 3–9 mm long; anther cells 0.8–1.4 mm long; lower and upper leaf surfaces about equally hairy, the cauline leaf widths 0.6–7 mm; not restricted to se AZ.
42. Leaf blades mostly linear to lanceolate, sometimes oblanceolate; calyx lobes ovate, the tips short acute to caudate *Penstemon linarioides*
- 42' Leaves mostly broader than lanceolate; calyx lobes lanceolate to linear, the tips sometimes long caudate.
43. Hairs on leaves strongly flattened and scale-like, strictly retrorse, usually up to 2–3 times longer than wide; mid stem leaves to 7 mm wide *Penstemon thompsoniae*
- 43' Hairs on leaves cylindrical to slightly flattened, retrorsely spreading and/or curled, usually 4 times or more longer than wide; mid stem leaves to 4 mm wide *Penstemon caespitosus*

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40' Plants not caespitose.

44. Anther cells hairy at the connective *Penstemon deaveri* (in part)

44' Anther cells glabrous, or at most, papillate (may be denticulate on the sutures).

45. Distal portion of staminodes glabrous (*P. spectabilis* sometimes hairy in the terminal 1 mm, *P. confusus* sometimes papillate, the papillae to 0.2 mm).

46. Corollas externally pubescent or glandular-pubescent (rarely glabrous in *P. confusus*).

47. Distal leaf blades 10–45 mm wide, ovate to lanceolate, connate-perfoliate to cordate-clasping, the margins usually dentate to serrate
..... *Penstemon spectabilis* (in part)

47' Distal leaf blades 1–17 mm wide, linear to elliptic to oblanceolate (rarely ovate in *P. utahensis*), petiolate to auriculate, not cordate-clasping, the margins entire, or at most papillate or scabrous.

48. Leaves green, not glaucous; anther cells navicular-bulging (open-ended navicular in *P. deaveri*), 1.1–2.3 mm long; thyse axes pubescent or glandular pubescent (glabrous in *P. stenophyllus*); s and e AZ.

49. Corollas 9–15 mm long from base to orifice, not obviously glandular puberulent, the lobes slightly glandular at most; anther cells open-ended navicular, 1.1–1.8 mm long; leaves spatulate, oblanceolate or elliptic, 3–22 mm wide; White and Pinaleno Mtns.; 2000–3500 m.....

..... *Penstemon deaveri* (in part)

49' Corollas 17–35 mm long from base to orifice, obviously glandular externally; anther cells navicular-bulging, 1.4–2.3 mm long; leaves linear, 1–9 mm wide; se deserts and sky islands, not known from the White Mtns.; 1000–2200 m.

50. Corollas red; anther cells often dehiscent proximally, indehiscent distally *Penstemon lanceolatus* (in part)

50' Corollas blue, violet, lavender to purple; anther cells fully dehiscent or sometimes slightly indehiscent proximally.

51. Thyse axes glandular-pubescent; inflorescence branches 1(–2) per node, 1(–2) flowered *Penstemon dasyphyllus*

51' Thyse axes glabrous; inflorescence branches (1–)2 per node, (1–)2–4(–5) flowered *Penstemon stenophyllus*

48' Leaves glaucous, anther cells explanate (less commonly open-ended navicular), 0.6–1.3 mm long; thyse axes glabrous; n AZ.

52. Corollas red; staminode glabrous; anther cell sutures smooth
..... *Penstemon utahensis* (in part)

52' Corollas reddish-violet to purple (rarely red); staminode glabrous or with distal 1–2 mm papillate, the papillae to 0.2 mm; anther cell sutures smooth or papillate *Penstemon confusus* (in part)

46' Corollas externally glabrous.

53. Staminodes usually pilose, rarely glabrous *Penstemon deaveri* (in part)

53' Staminodes glabrous.

54. Basal leaf blades oblanceolate, elliptic or spatulate 2–15(–20) mm wide
..... *Penstemon virgatus* (in part)

54' Basal leaf blades absent or linear to narrowly oblanceolate, 0.5–4(–6) mm wide.

55. Stems many-branched throughout, often shrubby; basal leaves absent go to couplet 24 (*P. ambiguus*, *P. thurberi*)

55' Stems few branched from base, not shrubby; basal leaves usually present (often deciduous later in the season).

56. Lower portions of stems glabrous; corolla lower lip hairy
..... *Penstemon putus* (in part)

56' Lower portions of stems retrorsely puberulent; corolla lower lip glabrous *Penstemon pseudoputus*

45' Distal 1.5 mm or more of the staminodes hairy.

57. Leaves thick, glaucous.

58. Leaf blade margins coarsely dentate, rarely entire; corollas abruptly and broadly expanded, the orifices 10-20(-24) mm wide *Penstemon palmeri* (in part)
- 58' Leaf blade margins entire; corollas gradually to abruptly expanded, the orifices 4-12 mm wide.
59. Anther cells 1.7-2.3 mm long *Penstemon nudiflorus*
- 59' Anther cells 0.7-1.6 mm long.
60. Inflorescence branches (1-)2-9(-10)-flowered.
61. Corollas 8-15 mm long from base to orifice, pink or blue; staminode hairy in the distal 2-3 mm, the hairs to 1.2 mm long; cauline leaves 2-12 pairs, lanceolate to narrowly elliptic, broadest leaves just below the inflorescence; Apache, Coconino, and Navajo cos. *Penstemon angustifolius*
- 61' Corollas 15-25 mm long from base to orifice, blue to violet; staminode hairy in the distal 4-9 mm, the hairs to 1.5(-2) mm long; cauline leaves 2-5(-6) pairs, ovate to lanceolate, about equally broad from base to inflorescence; Coconino and Mohave cos. *Penstemon pachyphyllus*
- 60' Inflorescence branches 1-3(-6)-flowered.
62. Peduncles 0-1 mm long; corollas 12-20 mm long from base to orifice, the throat scarcely expanded; staminode tips 0.8-1.6 mm wide, hairy, the hairs to 1.2 mm long; se AZ; 1150-1600 m (3700-5350 ft) *Penstemon fendleri*
- 62' Peduncles 0-30 mm long; corollas 11-16 mm long from base to orifice, the throat gradually expanded; staminode tips 0.6-1 mm wide, hairy, the hairs to 0.8 mm long; ne AZ; 1800-2600 m (5900-8550 ft) *Penstemon lentus*
- 57' Leaves not thick, not glaucous.
61. Stems glandular pubescent distally; thyrses clearly glandular-pubescent.
62. Staminodes distal 6-8 mm densely bearded; anthers horseshoe-shaped, fully dehiscent or proximally indehiscent, 1-2 mm long; inflorescence branches 1-2(-3)-flowered; Parashant and Whitmore canyons, Mohave Co.; 1100-1600 m (3800-5400 ft) *Penstemon distans* (in part)
- 62' Staminodes distal 3-6 mm densely bearded; anthers spreading, fully dehiscent or distally indehiscent, 0.7-1.3 mm long; inflorescence branches 1-10-flowered; Apache, Coconino, Greenlee, Navajo, Yavapai cos.; 2050-3100 m (6700-10,200 ft) *Penstemon oliganthus* (in part)
- 61' Stems not glandular-pubescent distally (thyrses sometimes slightly glandular-pubescent in *P. deaveri*)
63. Basal leaves absent or poorly developed; n Mohave Co. *Penstemon watsonii*
- 63' Basal leaves well-developed; Apache, Coconino, Graham and Greenlee Cos.
64. Cauline leaves dentate to serrate, up to 45 mm wide *Penstemon spectabilis* (in part)
- 64' Cauline leaves entire, up to 16 mm wide.
65. Inflorescence branches not congested, (1-)2-4(-6)-flowered; corolla orifice 6-9 mm wide; anther cells 1.1-1.8 mm long; White and Pinaleno Mtns., Apache, Graham, Greenlee cos. *Penstemon deaveri* (in part)
- 65' Inflorescence branches congested, (3-)5-11-flowered; corolla orifice 2-4 mm wide; anther cells 0.4-0.7 mm long; Kaibab Plateau and Chuska Mtns., Apache, Coconino cos. *Penstemon rydbergii*

Penstemon albomarginatus M. E. Jones (white-margined leaves) White-margin beardtongue.—Perennial herbs; caudex woody (proximal stems usually buried in sand and appearing rhizome-like). STEMS 4-30, 10-35 cm long, sprawling, often freely-branching,

glabrous, slightly glaucous. LEAVES basal and cauline, leathery, glabrous, the blades spatulate to obovate, the bases tapered, the margins entire (sometimes undulate), the scarious white margin 0.1–0.2 mm wide, the apices rounded to acute; basal leaves often not present at flowering; cauline leaves 2–5 pairs, 10–60 mm long, 5–22 mm wide, short-petiolate to sessile. THYRSES 5–15 cm long, continuous or interrupted, cylindric, the axes glabrous or obscurely glandular-pubescent, the verticillasters 3–12, the branches 2 per node, (1–)3–8-flowered; proximal bracts leaf-like, 20–63 mm long, 5–18 mm wide, oval to oblong, the margins white, entire, the apices acute to obtuse; peduncles and pedicels ascending to erect, glabrous or obscurely glandular-pubescent, the peduncles to 2 mm long, the pedicels 3–8 mm long. FLOWERS: calyx lobes oblong to lanceolate, 3–7 mm long, 1.2–2 mm wide, glabrous or obscurely glandular-pubescent, the margins white, entire or erose, scarious, glandular/papillate, the apices acute to mucronate; corolla ampliate-funnelform, strongly bilabiate, 9–14 mm long from base to orifice, pinkish lavender, reddish- or violet-lined internally on the lower surface, externally glabrous, internally yellowish pilose on the lower surface with flat hairs that pass onto the limb; tube 4–6 mm long, the throat gradually expanded, the orifice 4–6 mm wide, the lower lobes projecting, the upper lobes projecting-spreading; stamens included; anther cells fully dehiscent, explanate, 0.7–1.4 mm long, the sides glabrous, the sutures smooth; staminodes reaching orifice or exserted, glabrous, the tip 0.2–0.4 mm wide, straight to slightly recurved. CAPSULES 7–13 mm long, 4.5–7 mm wide, glabrous. SEEDS 2–3 mm long, dark brown. $2n = 16$.—Sand, desert scrub; of conservation concern; Mohave Co.; 540–920 m (1700–3100 ft); range map: Fig. 14A; Mar–Jun; CA, NV.

Glenn Clifton (pers. comm.) has suggested that AZ plants are different enough from CA and NV plants to be given specific status. The population genetics work of Wolfe *et al.* (2016) suggests a postglacial dispersal northward from the s (AZ and CA) populations.

Penstemon ambiguus Torr. (“uncertain”, probably referring to the unusual appearance of the flowers and its relationship to *Penstemon*) Gilia beardtongue.—Perennial herbs to shrubby. STEMS (1–)5–100+, 15–60 cm tall, many-branched throughout, forming a round subshrub, glabrous. LEAVES cauline only, 5–25 pairs, 4–25 mm long, 0.5(–1.5) mm wide, sessile, the margins glabrous or scabrous, mucronate. THYRSES 1–15 cm long, often many-branched, glabrous, the verticillasters 1–12, the inflorescence branches (1–)2 per node, 1-flowered; proximal bracts leaf-like, linear, 1–12 mm long, 0.3–0.5 mm wide, the margins entire to slightly scabrous, the apices mucronate; peduncles to 12 mm long, the pedicels 1–8 mm long. FLOWERS: calyx lobes ovate, 1.2–2 mm long, 0.8–1.5 mm wide, the margins entire or erose, broadly scarious, the apices broadly acuminate; corolla appearing salverform, but the lower lobes projecting (spreading), the upper lobes reflexed (spreading), pink or white (dried specimens sometimes fade to some shade of blue), externally glabrous, internally pubescent, the hairs 0.4 mm long, 8–14 mm long from the base to the orifice, the orifice 2–5 mm wide, the limb 7–17 mm wide, mostly spreading in one plane; stamens included, the anther cells fully dehiscent, explanate (sometimes not as laid out flat as is typical for this anther cell type), 0.6–

0.65 mm long, glabrous; staminodes glabrous. CAPSULES 4–9 mm long, 2.5–5 mm wide, glabrous. SEEDS dark brown, 1–2.7 mm long. $2n = 16$.—2 vars., only var. *laevissimus* in AZ.—Sandy soil in Great Basin Shrubland and Pinon Juniper woodlands, n and e of the Mogollon Rim; Apache, Coconino, Navajo cos; 950–2200 m (3100–7200 ft); range map: Fig. 14A; May–Aug(–Sep); w US, n Mex.—*Penstemon ambiguus* Torr. var. *laevissimus* (D. D. Keck) N. H. Holmgren.— [*Penstemon ambiguus* subsp. *laevissimus* D. D. Keck]

Penstemon angustifolius Pursh (narrow leaved) Narrow-leaf beardtongue.—Perennial herbs; caudex woody. STEMS 1–3(–10), 10–55 cm tall, ascending to erect, glabrous. LEAVES thick, glabrous, glaucous, papillate-textured, raised veins often present on both surfaces, the margins entire, white-rimmed; basal leaves typically narrower than the cauline leaves, the basal and proximal cauline leaves crowded, 20–90 mm long, (2–)5–18 mm wide, the blades narrowly oblanceolate, with bases tapered, petiolate, the apices acute to rounded; cauline leaves 2–12 pairs, 18–100 mm long, 10–20 mm wide, the blades lanceolate to narrowly elliptic, the broadest leaves just below the inflorescence, sessile, the bases tapered to cordate-clasping, the apices acute. THYRSES 4–30 cm long, continuous to interrupted, cylindric, the axes glabrous, the verticillasters 3–12, the inflorescence branches 2 per node, (1–)2–8(–10)-flowered, often not maturing to fruit; proximal bracts lanceolate (upper bracts graduating to broadly ovate), (3–)12–45 mm long, 2–28 mm wide, the margins entire, the apices acuminate; peduncles and pedicels ascending to erect, glabrous, the peduncles 0–8 mm long, the pedicels 1–8 mm long. FLOWERS: calyx lobes ovate to lanceolate, 3–6 mm long, 1.3–2.5 mm wide, glabrous, the margins entire or erose, not scarious margined to broadly scarious basally, the apices acuminate; corolla tubular-funnelform, bilaterally symmetric, weakly bilabiate, 8–15 mm long from base to orifice, pink to blue (white), faintly violet or reddish purple lined internally on both surfaces, externally glabrous, internally sparsely white-pubescent and/or glandular on the lower surface or glabrous; tube 5–8 mm long; throat gradually expanded, the orifices 4–6(–8) mm wide, the lobes spreading; stamens included or longer pair reaching orifice, the anthers spreading, the cells fully dehiscent, navicular, 0.8–1.5 mm long, the sides glabrous, the sutures papillate; staminode reaching orifice, distal 2–3 mm sparsely to densely villous with golden yellow (white) hairs to 1.2 mm long (hairs on proximal part of staminode mostly along margins), the tip 0.9–1.7 mm wide, recurved. CAPSULES 8–15 mm long, 7–10 mm wide, raised veins often present. SEEDS dark brown, irregular, alveolate, angled, 1–3.2 mm long. $2n = 16$. —5 vars. acc to Freeman (2019): 2 vars. in AZ.—sandy places in Great Basin Shrubland to Pinyon Juniper Woodland; Apache, Coconino, Navajo cos; 1500–2300 m (5000–7400 ft); range map: Fig. 14B; Apr-Sep; c Rockies into the Great Plains.

According to Freeman (2019), AZ specimens are *P. angustifolius* Pursh var. *venosus* (D. D. Keck) N. H. Holmgren. However, our plants do not conform to this variety. Instead, our specimens take two forms that can be keyed below. Regardless of whether we include the larger-flowered variety in var. *venosus*, we should recognize the smaller blue-flowered form as a novel variety.

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1. Flowers pink (rarely blue), 13–15 mm long from base to orifice; floral bracts ovate to lanceolate; anther cells 1.1–1.5 mm long; peduncles 0–4 mm; staminode hairs yellow; found on sand in n Apache, Coconino, and Navajo cos..... *Penstemon angustifolius* (large-flowered)
- 1' Flowers blue, 8–10 mm long from base to orifice; floral bracts linear to lanceolate; anther cells 0.8–1.2 mm long; peduncles 4–8 mm; staminode hairs white; found on fine substrates in s Apache and Navajo cos. *Penstemon angustifolius* (small-flowered)

Penstemon angustifolius and *P. lentus* are nearly sympatric and could be confused. Use the following key to separate them.

1. Cauline leaves 2–12 pairs, 10–20 mm wide, the bases tapered to cordate-clasping, the apices acute; inflorescence branches (1–)2–8(–10)-flowered; flowers pink (rarely blue or white) *Penstemon angustifolius*
- 1' Cauline leaves 2–4 pairs, 7–30 mm wide, the bases clasping to cordate-clasping, the apices rounded; inflorescence branches 1–3(–6)-flowered; corollas blue (rarely white) *Penstemon lentus*

Penstemon angustifolius and *P. fendleri* could also be confused. *Penstemon fendleri* occurs to the se in Cochise, Graham, and Greenlee cos. Use the following key to separate them:

1. Flowers 8–15 mm long from base to orifice; basal leaves tending to be narrower than the cauline leaves; cauline leaves crowded (due to shorter internodes and more leaf pairs (2–12)); stem leaves more long-acuminate; inflorescence more congested; more likely to have glands inside and outside the corolla..... *Penstemon angustifolius*
- 1' Flowers 12–20 mm long from base to orifice; basal leaves tending to be as broad or broader than cauline leaves; cauline leaves not crowded (due to longer internodes and fewer leaf pairs (2–7)); stem leaves more trullate; inflorescence more interrupted; less likely to have glands inside and outside the corolla..... *Penstemon fendleri*

Penstemon barbatus (Cav.) Roth (bearded) Beard-lip beardtongue.—Perennial herbs; caudex woody. STEMS 1–3, 30–100 cm tall, mostly erect, sometimes ascending, glabrous or obscurely puberulent proximally, usually slightly glaucous. LEAVES usually glabrous, rarely short hairy, the bases blunt, cuneate or tapered; basal and proximal cauline leaves crowded, 22–140 mm long, 6–42 mm wide, the blades oblanceolate, petiolate, the margins entire, the apices obtuse, acute, or acuminate; cauline leaves (3–)5–11(–14) pairs, 28–160 mm long, 2–25 mm wide, the blades lanceolate to linear, sessile, the apices acute. THYRSES 11–69 cm long, usually somewhat secund, sometimes cylindric, the axes glabrous, verticillasters 5–16(–19), the inflorescence branches 2 per node, (1–)2–6-flowered; proximal bracts leaflike, linear, 10–70(–126) mm long, 1–6(–10) mm wide, the margins entire, the apices acute; peduncles and pedicels spreading to ascending, glabrous, the peduncles to 45 mm, the pedicels 2–37(–48) mm long. FLOWERS: calyx lobes ovate to lanceolate, 3.5–10 mm long, 1.5–3.2 mm wide, glabrous, the margins entire or erose, broadly scarious, the apices acute; corolla tubular-funnelform, strongly bilabiate, 10–24 mm long from the base to the orifice, red, dark red-lined on the lower surface, externally glabrous, internally glabrous or sparsely white-lanate or yellow-lanate on the lower surface; tube 5–8 mm, the orifice 4–8 mm wide, the lobes often

linear, the lower lobes strongly reflexed or less-commonly projecting, 3–5 mm long, the upper lobes projecting, (5–)7–10 mm long, fused to within 1.5–3 mm of their apices; stamens exerted, the anthers spreading, the cells scoop-shaped, the connective and proximal 1/4–1/3 indehiscent, 1.5–2.2 mm long, less than two times as long as wide, the sides glabrous, the sutures papillate or denticulate, the teeth to 0.06 mm or smooth; staminodes glabrous, the tip 0.3–0.6 mm wide, tip straight or slightly recurved. CAPSULES 7–16 mm long, 4–9 mm wide. SEEDS 1.8–2.7 mm long, brown. $2n = 16$. [*Chelone barbata* Cav.; *Penstemon barbatus* var. *barbatus*; *Penstemon barbatus* var. *torreyi*].—high desert to subalpine forest; all counties except La Paz and Yuma; 1000–3200 m (3600–10,500 ft); range map: Fig. 14C; May–Nov; CA, CO, IN, NB, NM, NV, TN, TX, UT; Mex. (Chi., Coah., DF, Dgo., Hgo., N. L., Pue., S. L. P., Sin., Son., Tamps., Ver., Zac.).

Several authors (Kearney & Peebles 1960, Cronquist *et al.* 1984, McDougall 1974, Freeman 2019) treated three varieties. Here, variety *trichander* is elevated to species, following Rydberg (1906). This interpretation is based on the consistent character of hairs on the anther cells, stems, and leaves, which are absent on the other two varieties (rarely the stems and leaves are slightly hairy on *Penstemon barbatus* sensu strictu). Also *P. trichander* is endemic to the Four Corners region; allopatric with *P. barbatus*. Here, varieties *torreyi* and *barbatus* are not recognized. These two varieties have been separated based on yellow vs. white hairs (or lack of hairs) on the inside lower surface of the corolla. Hair color is barely discernable from nearly white to pale yellow and does not have a strong correlation with range in AZ. These varieties may make more sense regionally. Specimens in herbaria are still determined as both *P. b.* var. *barbatus* and *P. b.* var. *torreyi*. *Penstemon barbatus* is among the most widespread and conspicuous species of *Penstemon* in the desert sw. Putative hybrids reported between *P. barbatus* and *P. comarrhenus*, *P. strictus*, and *P. virgatus* were summarized by Crosswhite (1965).

Rarely *Penstemon barbatus* has corollas that are axially symmetric, appearing similar to *P. eatonii*, perhaps indicative of introgression. In these cases, the two can be differentiated using the following key:

1. Anthers horseshoe-shaped, the cell lengths >2X width, the dehiscent slits directed to the side; mid-stem leaves blunt to cordate-based..... *Penstemon eatonii*
- 1' Anthers spreading, the cell lengths <2X width, the dehiscent slits directed up and away from the filament; mid stem leaves cuneate to blunt, not cordate-based..... *Penstemon barbatus*

Penstemon bicolor (Brandegge) Clokey & D. D. Keck (two color phases, yellow and pink) Two-color beardtongue.—Perennial herbs; caudex woody. STEMS 1–40+, 20–180 cm tall, ascending to erect, glaucous. LEAVES spreading, thick, leathery, glaucous; basal and proximal cauline leaves crowded, 30–130 mm long, 10–95 mm wide, the blades ovate, the bases tapered, petiolate, the apices obtuse to acute; cauline leaves 3–8 pairs, 25–110 mm long, 10–55 mm wide, the blades lanceolate, sessile to connate-perfoliate, the margins dentate, the apices acute to acuminate. THYRSES 16–90 cm long, interrupted, secund, the axes glandular-pubescent, the verticillasters 6–23, the inflorescence branches 2 per node, 1–6-flowered;

proximal bracts ovate to lanceolate, 8–40 mm long, 3–30 mm wide, the margins entire or dentate, the apices acuminate, the lower side densely glandular-pubescent, the upper side glandular-pubescent or glabrous; peduncles and pedicels ascending to erect, glandular-pubescent, the peduncles to 15 mm long, the pedicels 3–25 mm long. FLOWERS: calyx lobes ovate, 4–6 mm long, 2.2–4 mm wide, externally glandular-pubescent, internally usually glandular-pubescent, sometimes nearly glabrous, the margins entire or erose, scarious to pink or purple, the apices acute; corolla ventricose, strongly bilabiate, 10–20 mm from base to orifice, light yellow, pink to rose-pink, or purple (in AZ), reddish or reddish purple lined or unlined extending onto the lobes of limb; externally and internally glandular-pubescent, also often sparsely to densely long hairy on the lower surface of the orifice, the hairs flat, white or yellowish, the tube 7–8 mm, (1–2 times as long as calyx lobes), the throat gradually and narrowly expanded, constricted at orifice, the orifice 6–9 mm wide, the lobes 4–5 mm long and wide, the lower lobes projecting-spreading, the upper lobes projecting to spreading or reflexed; stamens: longer pair reaching orifice or exserted, filaments of shorter pair sparsely glandular-puberulent at bases, the anthers spreading, the cells explanate, 1.4–1.8 mm long, 0.6–1 mm wide, the septa heights less than one half the width of the cell walls, the sutures smooth; staminode included to slightly exserted, proximal 3–4 mm glandular-puberulent, distal 4–5 mm hairy with flat, yellow hairs to 2.8 mm long, the tip 0.3–0.4 mm wide, recurved; style glabrous. CAPSULES 5–13 mm long, 4–7 mm wide, glabrous or sparsely glandular-pubescent distally. SEEDS 1.2–2.2 mm long, dark brown, angled. [*Penstemon palmeri* A. Gray var. *bicolor* Brandegee, Univ. Calif. Publ. Bot. 6: 360. 1916 (as *Pentstemon*); *P. bicolor* subsp. *roseus* Clokey & D. D. Keck; *P. pseudospectabilis* M. E. Jones subsp. *bicolor* (Brandegee) D. D. Keck].—Gravelly soil in arroyos, roadsides, talus slopes, roadsides, desert scrub, and juniper woodlands; w Mohave Co; 900–1200 m (3000–4000 ft); range map: Fig. 14D; Mar–May (Jun); CA, NV.

Prior treatments (Kearney and Peebles 1960, McDougall 1973) recognized two subspecies based on corolla color. Subspecies *bicolor* has light yellow corollas and subsp. *roseus* has pink to purple corollas. Later authors (Freeman 2019, Smith 2005) considered these color phases without subspecific recognition. Our plants have pink to purple corollas.

Penstemon bicolor is most often confused with *P. palmeri* and *P. pseudospectabilis*. The corollas and corolla orifices of *Penstemon palmeri* are much broader than those of *P. bicolor*. Hybrids with *P. palmeri* are known (Smith 2005). The following key gives characters not in the main key that should help to discern *P. bicolor* from *P. pseudospectabilis*.

1. Corolla with hairs on the upper interior; staminode hairy, the hairs to 2.8 mm long; peduncles and pedicels 0.4–0.7 mm thick, more glandular; calyx lobes 4–6 mm long; often in washes..... ***Penstemon bicolor***
- 1' Corolla lacking hairs on the upper interior; staminode lacking hairs or hairy, the hairs to 1.5 mm long; peduncles and pedicels 0.4–0.6 mm thick, less glandular; calyx lobes 3–4.5 mm long; often in rocky places..... ***Penstemon pseudospectabilis***

Penstemon breviculus (D. D. Keck) G. T. Nisbet & R. C. Jackson (short) Short-stem beardtongue.—Perennial herbs; caudex woody, branching underground, not matt-forming. STEMS 1–10, 5–30 cm tall, ascending to erect, retrorsely puberulent, distally glandular puberulent. LEAVES not leathery, glabrous to sparsely puberulent; basal and proximal cauline leaves crowded, 10–70 mm long, 2–18 mm wide, the blades oblanceolate to linear, the bases tapered, petiolate, the margins entire or dentate, the apices rounded to acute; cauline leaves 2–4 pairs, 20–70 mm long, 2–15 mm wide, the blades narrowly oblanceolate to linear, the bases petiolate to sessile, sometimes clasping, the margins entire, dentate, or crisped, the apices obtuse to acute. THYRSES 4–15 cm long, continuous or interrupted, cylindric, the axes glandular-pubescent, the verticillasters 3–7, the inflorescence branches (1–)2 per node, 2–7-flowered; proximal bracts leaf-like, elliptic to linear, 16–55 mm long, 2–12 mm wide, the margins entire, crisped, or obscurely serrate, the apices acute; peduncles and pedicels ascending to erect, glandular-pubescent, the peduncles to 16 mm long, the pedicels 1–10 mm long. FLOWERS: calyx lobes lanceolate, 4–9 mm long, 1.2–2.6 mm wide, equally glandular-pubescent internally and externally, the margins entire, scarious, the apices acute; corolla ampliate, bilabiate, bilaterally symmetric, 8–15 mm long from base to orifice, dark blue to violet or purple, reddish violet-lined internally (sometimes externally) usually passing onto the limb, the tube 4–6 mm long, the throat often abruptly expanded, sometimes constricted at orifice, the orifice 3–6 mm wide, the lobes projecting to spreading, externally glandular-pubescent, yellowish or whitish hairy internally on the lower surface, the hairs flat, long, yellowish or whitish; stamens included, the anthers spreading, the cells explanate, fully dehiscent, 0.6–1 mm long, the sutures smooth, the septa heights less than one half the width of the cell walls; staminode reaching orifice or exserted, distal 5–8 mm densely hairy with flat, orangish yellow hairs to 1.8 mm, the medial hairs shorter, stiffer, retrorse, the staminode tip flattened, 0.3–0.6 mm wide, straight to recurved. CAPSULES 6–9 mm long, 4–6 mm wide, glabrous. SEEDS dark, 2.2–3.2 mm long. [*Penstemon jamesii* Ben. subsp. *breviculus* D. D. Keck].—Sandy to clay soils in sagebrush shrublands, pinyon-juniper woodlands, and desert grasslands; n Apache Co.; 1800–2300 m (5900–7600 ft); range map: Fig. 14D; Apr–Jun; CO, NM, UT.

Penstemon caespitosus Nuttall ex A. Gray Mat (tufted) beardtongue.—Cespitose, mat-forming, branching underground. STEMS 3–100+, 2–8 cm long, prostrate (the tips ascending), retrorsely puberulent the hairs pointed. LEAVES cauline, 3–10 (–20+) pairs, the blades obovate to spatulate, oblanceolate, 2.5–10(–15) mm long, 1–4 mm wide, the bases tapered, petiolate, the margins entire, the apices mucronate, puberulent, lower and upper leaf surfaces about equally hairy, the hairs cylindrical to slightly flattened, usually 4 times or more longer than wide, retrorsely spreading and/or curled. THYRSES 0.5–3(–6) cm long, continuous, branching, cylindric to secund, the axes retrorsely puberulent to retrorsely cinereous, sometimes also glandular-pubescent, the verticillasters 1–8, the inflorescence branches 1(–2) per node, 1–3-flowered; proximal bracts leaflike, 2.8–13 mm long, 0.7–3 mm wide; peduncles and pedicels ascending to erect, retrorsely puberulent and glandular-pubescent, the peduncles

to 2 mm long, the pedicels 0.5–2 mm long. FLOWERS: calyx lobes linear to lanceolate, 3.5–7(8) mm long, 1–2 mm wide, (calyx tube 0.2–1 mm long), retrorsely puberulent with pointed hairs, sparsely glandular-pubescent, the margins entire, herbaceous or narrowly scarious, hyaline margins along upper $\frac{1}{2}$ (rarely $\frac{2}{3}$), the apices usually long caudate, sometimes merely acute; corolla ampliate-funnelform, 9–15 mm long from base to orifice, blue to lavender, reddish violet-lined internally on the lower surface, internally yellow-villous on the lower surface, externally glandular puberulent; tube 5–6 mm long; throat gradually expanded, the orifice 4–7 mm wide, the lower lobes projecting, the upper lobes spreading; stamens: longer pair reaching orifice or exserted, the filaments glabrous, the anthers spreading, the cells fully dehiscent, navicular, 0.85–1.1 mm long, the surfaces and sutures papillate; staminode reaching orifice or slightly exserted, distal 4–7 mm densely pilose with golden yellow hairs to 1.2 mm, the tip flattened, 0.3–0.5 mm wide, straight to recurved. CAPSULES 4–6 mm long, 3–4 mm wide. SEEDS dark brown, angled to rounded-globular, 1.5–2 mm. $2n = 16$. [*P. caespitosus* subsp. *desertipicti* (A. Nelson) D. D. Keck, *Penstemon desertipicti* A. Nelson]. Varieties 3, 1 in AZ; *Penstemon caespitosus* Nuttall ex A. Gray var. *desertipicti* (A. Nelson) N. H. Holmgren.—Gravelly to clay soil in sagebrush shrublands and pine woodlands; Apache, Coconino, Mohave, Navajo cos; 1500–2200 m (5200–7100 ft); range map: Fig. 15E; May–Sep; CO, UT, WY.

Similar species: *Penstemon caespitosus* is often confused with *P. thompsoniae*. Many specimens separate easily based on characters given in the key, but many have hair characters that are intermediate between the ‘pointed’ hairs described for *P. caespitosus* and the ‘scale-like’ hairs described for *P. thompsoniae* (Freeman 2019). Further complicating things, Freeman (2019) includes within *P. thompsoniae*, specimens which others would place with *P. caespitosus*. I have not seen specimens from AZ that Freeman considers *P. caespitosus*. Both Holmgren (1984) and Stevens *et al.* (2020) treat *P. caespitosus* as the more inclusive and *P. thompsoniae* as the more exclusive taxon, based on leaf widths. It is tempting to classify *P. thompsoniae* as a variety of *P. caespitosus*, as Nelson (1937) did. However, the molecular work of Wolfe *et al.* (2006) suggests that they may be more distantly related. This treatment follows the approach of Holmgren (1984) and of Stevens *et al.* (2020), but specimens are still annotated by Freeman as *P. thompsoniae* (especially at ASU) that this author would call *P. caespitosus*. Unfortunately, this confusion is reflected in the range map shown in Fig. 15(E).

Penstemon centranthifolius (Benth.) Benth. (*Centranthus*-like leaves) Scarlet bugler.—Perennial herbs; caudex woody. STEMS 1–5, 30–120 cm tall, ascending to erect, glaucous. LEAVES essentially cauline, leathery, glabrous, glaucous; cauline leaves 5–11 pairs, 20–80 mm long, 10–40 mm wide, the blades ovate to lanceolate, the bases sessile, truncate to auriculate-clasping, the margins entire, the apices rounded to acute. THYRSES 8–90 cm, interrupted, secund to somewhat cylindric, the axes glabrous, the verticillasters 6–27, the inflorescence branches 2 per node, 1–5(–11)-flowered; proximal bracts leaflike, ovate to lanceolate, 6–70 mm long, 3–35 mm wide, the margins entire, the apices acute to acuminate;

peduncles and pedicels erect, glabrous, the peduncles to 20 mm, the pedicels 3–25 mm. FLOWERS: calyx lobes ovate to lanceolate, 3–6 mm long, 2–3 mm wide, glabrous, the margins erose, broadly scarious, the apex acute; corolla tubular, nearly radially symmetric, weakly bilabiate, 18–32 mm long from the base to the orifice, deep red, externally and internally glabrous, unlined internally; tube 8–14 mm; throat scarcely expanded, the orifice 3.5–7 mm wide, the lobes projecting-spreading; stamens: longer pair reaching orifice, the anther cells fully dehiscent, explanate, 0.9–1.2 mm long, the sutures smooth, the septa heights less than one half the width of the cell walls; staminode glabrous, the tip terete to slightly flattened, 0.1–0.3 mm wide, straight. CAPSULES 8–15 mm long, 5–8 mm wide. SEEDS dark brown, 2–3.8 mm; $2n = 16$.—Oak woodland and shrubland; presumably introduced to AZ, presently restricted to the Mt. Lemmon Highway, Santa Catalina Mtns., Pima Co.; 1300–1400 m (4300–4600 ft); Apr; range map: Fig. 15F; Calif.; Mex. (Baja C.)

Perhaps introduced to the WWII era Japanese internment camp in the Santa Catalina Mtns. where it is known to have persisted for at least ten years and may be naturalizing. With *Lindley 41* (ARIZ), now known from further up the Mt. Lemmon Hwy. as far as the Bug Spring Trailhead. These plants have been confused with *Penstemon eatonii*, which has much longer anther cells that are not explanate like those of *P. centranthifolius*. *Penstemon centranthifolius* more closely resembles *P. subulatus*, but has broader stem leaves. In CA, it has longer flowers, but here the flower length is similar to those of *P. subulatus*. *Penstemon centranthifolius* could also be confused with *P. superbus*, but *P. centranthifolius* staminodes are glabrous, while those of *P. superbus* have hairs near the tip.

Penstemon clutei A. Nelson (Willard Nelson Clute (1869–1950), founder of the American Fern Society) Sunset Crater beardtongue.—Perennial herbs; caudex woody. STEMS 1–15+, 30–80 cm tall, ascending to erect, glaucous. LEAVES spreading, thick, leathery, glaucous; basal and proximal cauline leaves crowded, 25–100 mm long, 5–30 mm wide, the blades lanceolate to elliptic, the bases tapered, petiolate, the margins coarsely dentate or serrate, the apices acute to obtuse; distal cauline leaves, 4–6 pairs, 10–80 mm long, 3–35 mm wide, the blades ovate to lanceolate, the bases tapered or auriculate-clasping to connate-perfoliate on the distal-most leaves, the margins coarsely dentate to entire on distal leaves, the apices acuminate to obtuse. THYRSES 5–50 cm long, interrupted, secund, the axes glabrous or sparsely glandular-pubescent distally, the verticillasters 3–16, the inflorescence branches 2(–1) per node, 1–4-flowered, the proximal bracts leaf-like, ovate to triangular, 5–50 mm long, 3–40 mm wide, glabrous or glandular puberulent, the margins coarsely dentate, sometimes entire, the apices acuminate to obtuse; peduncles and pedicels ascending to erect, glandular-pubescent, the peduncles to 14 mm, the pedicels 2–15 mm. FLOWERS: calyx lobes ovate to elliptic, 3.5–5.5 mm long, 2.5–3.5 mm wide, glandular-pubescent, the margins erose, scarious to pink-margined, the apices acute to caudate; corolla ventricose, strongly bilabiate, (10–)15–23 mm long from base to orifice, pink to rose-pink, reddish purple-lined internally on the lower surface extending onto the lobes of limb, externally and internally glandular-pubescent,

glandular hairy at the orifice, lacking hairs internally; tube 5–10 mm long (about twice as long as the calyx); throat gradually to abruptly expanded, not constricted at orifice, the orifice 8–12 mm wide, the lower lobes spreading, the upper lobes projecting-spreading; stamens: longer pair reaching orifice, filaments sometimes glandular pubescent in the lower half, the anthers spreading, the cells explanate, fully dehiscent, 1.2–1.6 mm long, 1.0–1.3 mm wide, the sutures smooth, the septa heights less than one half the width of the cell walls; staminode exerted, the lower half sometimes sparsely glandular-pubescent, glabrous or distal 1–4 mm hairy, with white to yellow hairs to 1.4 mm long, the tip 0.4–0.6(–1) mm wide, straight; style glabrous. CAPSULES 9–14 mm long, 5–8 mm wide, glabrous. SEEDS 1–2 mm long, dark brown to black, angled; $2n = 16$; [*Penstemon pseudospectabilis* M. E. Jones subsp. *clutei* (A. Nelson) D. D. Keck].—pine forests; edaphic endemic to cinders in the San Francisco Volcanic Field, Coconino Co.; 1800–2500 m (5900–8100 ft); range map: Fig. 15F; Apr–Sep; of conservation concern.

Penstemon clutei is most often confused with *P. pseudospectabilis*, especially *P. p.* var. *pseudospectabilis* since both have glandular pedicels and calyces. Use this key to separate them:

1. Corolla throats gradually to abruptly expanded; orifices 8–12 mm wide.....*Penstemon clutei*
- 1' Corolla throats not so abruptly and broadly expanded; orifices 5–9(–12) mm wide..... *P. pseudospectabilis*

Penstemon cobraea Nutt. (probably for the similarity of its flowers to those of *Cobaea scandens*) Cobaea beardtongue.—Perennial herbs; caudex woody. STEMS 1–4, (15–)25–65(–100) cm, ascending to erect, proximally puberulent, distally glandular-pubescent. LEAVES basal and cauline, sometimes basal leaves absent or withering, not leathery to somewhat leathery, glabrous to pubescent; basal and proximal cauline leaves 35–120(–150) mm long, 4–55(–76) mm wide, blade spatulate to oblanceolate or elliptic, base tapered, petiolate, margins subentire or serrate to dentate, apex rounded to acute; cauline leaves 4–8 pairs, 35–120(–150) mm long, 10–45(–54) mm wide, blade ovate to lanceolate, sessile, tapered to cordate-clasping, margins subentire to serrate or dentate, apex acute, rarely obtuse. THYRSES 10–30(–52) cm, interrupted to continuous, cylindric, axes densely glandular-pubescent, verticillasters 3–6(–8), the inflorescence branches 2 per node, 2–6-flowered; proximal bracts ovate, 20–78 mm long, 8–74 mm wide, margins entire or serrulate, rarely serrate, apex acute; peduncles and pedicels ascending to erect, densely glandular-pubescent, peduncles to 23 mm, pedicels 1–13 mm. FLOWERS: calyx lobes ovate to lanceolate, (8–)10–16 mm long, 2.5–4.5 mm wide, densely glandular-pubescent, margins entire, narrowly scarious, apex acute; corolla ventricose-ampliate, bilaterally symmetric, strongly bilabiate, 25–45 mm long from base to orifice, white to pink or violet to purple, reddish purple-lined internally on the lower surface, sometimes on upper surface, externally and internally glandular-pubescent externally; tube 10–14 mm; throat abruptly expanded, slightly constricted at orifice, the orifice 12–30 mm wide, the lower lobes spreading or reflexed, the upper lobes projecting-spreading; stamens included, anther cells fully dehiscent, explanate, 1.3–2.2 mm, sutures smooth, the septa heights less than one half the

width of the cell walls; staminode 23–30 mm long, included or barely exerted, distal 20–25 mm sparsely to moderately villous with white to golden yellow hairs to 3.5 mm long, the tip flattened, 0.6–0.9 mm wide, recurved. CAPSULES 13–18 mm long, 8–10 mm wide, glabrous. SEEDS 2.5–3.5 mm, black, angled; [*P. hansonii* A. Nelson].—pine woodlands; Yavapai Co.; 1100–1700 m (3600–5500 ft); range map: Fig. 15F; May–Jun; Great Plains.

Penstemon cobaea is an uncommon introduced species in AZ. Our specimens are var. *cobaea* with white corollas.

Penstemon comarrhenus A. Gray (woolly nose, referring to the anther hairs) Dusty beardtongue.—Perennial herbs; caudex woody. STEMS 1–4, 25–100+ cm tall, ascending to erect, glabrous or, sometimes, proximally retrorsely puberulent, pale green. LEAVES not leathery to somewhat leathery, densely retrorsely puberulent to glabrous, pale green, not glaucous, the bases tapered, the margins entire; basal and proximal cauline leaves crowded, 30–110 mm long, 3–20(–30) mm wide, the blades obovate to oblanceolate, petiolate, the apices rounded to acute; cauline leaves 5–8 pairs, 10–110 mm long, 1–10(–20) mm wide, blades oblanceolate to linear, glabrous or retrorsely cinereus, sessile, the apices obtuse to acute. THYRSES 8–50 cm long, often open, diffuse and interrupted, the axes glabrous, the verticillasters 5–15, the inflorescence branches 1(–2) per node, 1–3(–12)-flowered; proximal bracts leaflike, lanceolate to linear, 8–84 mm long, 1–6 mm wide, the margins entire, the apices acute, glabrous or retrorsely cinereus; peduncles spreading to ascending, glabrous, the peduncles to 44 mm, the pedicels 1–10(–24) mm. FLOWERS: calyx lobes ovate, (2.2–)3.5–4.5 mm long, 2–3.4 mm wide, glabrous, the margins erose or entire, scarious margined, the apices obtuse to caudate; corolla ventricose, strongly bilabiate, 15–25 mm long from base to orifice, pale blue to lavender, violet-lined internally on the lower surface, externally and internally glabrous; tube 8–10 mm long; throat abruptly expanded, not or only slightly constricted at orifice, 7–14 mm wide, the lower lobes spreading to reflexed, the upper lobes arched-projecting, stamens: longer pair exerted, the anthers divergent to nearly spreading, the cells scoop-shaped, with the connective and proximal 1/5 indehiscent, straight or slightly sigmoid, 2–2.2 mm long, the sides densely villous or lanate, the hairs white, to 2.5 mm, the sutures papillate or denticulate, the teeth to 0.1 mm; staminode included, glabrous or distal 1–2 mm sparsely pilose with white hairs to 1 mm long, the tip straight or slightly recurved, 0.8–1 mm wide. CAPSULES 5–8 mm long, 3–5 mm wide. SEEDS 1.5–2.4 mm long tan to brown, angled.—pine to subalpine woodlands; Apache, Coconino, Navajo cos; 1700–2600 m (5700–8500 ft); range map: Fig. 15G; Jun–Aug; CO, NV, NM, UT.

In some cases *Penstemon comarrhenus* may be difficult to discern from *P. strictus*. Use the following key:

1. Anther cells 2–2.2 mm long, more densely lanate; staminode glabrous or with distal 1–2 mm sparsely hairy; corollas pale blue, more abruptly expanded beyond the tube; peduncles to 44 mm long *Penstemon comarrhenus*

1' Anther cells 1.3–2 mm long, less densely lanate; staminode glabrous or with distal 1–5 mm sparsely hairy, corollas pale to dark blue, less broadly expanded beyond the tube; peduncles to 13 mm long *Penstemon strictus*

Also, see notes after the *P. strictus* description.

Penstemon confusus M. E. Jones (confused with *P. acuminatus*) Owens Valley beardtongue.—Perennial herbs; caudex woody. STEMS 1–4, erect, 15–50 cm tall, glaucous. LEAVES leathery, glabrous or (basal) obscurely papillate scabrous, glaucous, the margins entire to obscurely papillate; basal and proximal cauline leaves crowded, 30–140 mm long, 2–16 mm wide, the blades oblanceolate, the bases tapered, petiolate, the apices obtuse, sometimes mucronate; cauline leaves 2–4 pairs, 10–55 mm long, 2–15 mm wide, the blades lanceolate to linear, the bases sessile, tapered to cuneate in the wider leaves, the apices obtuse to acute, sometimes mucronate. THYRSES 5–45 cm long, somewhat secund, the axes glabrous, the verticillasters 5–13, the inflorescence branches 2 per node, 1–5-flowered; proximal bracts leaflike, lanceolate, 7–30 mm long, 1–12 mm wide, the margins entire, apices acute; peduncles and pedicels ascending to erect, glabrous, the peduncles to 17 mm long, the pedicels 1–14 mm long. FLOWERS: calyx lobes ovate to obovate (rarely elliptic), 3–4 mm long, 1.5–3 mm wide, glabrous or sparsely glandular on the margins, the margins entire or erose, broadly scarious or rosy-margined, the apices obtuse to acute, sometimes mucronate; corolla tubular-funnelform, bilaterally symmetric, slightly bilabiate, 12–17 mm long from base to orifice, reddish violet to purple (rarely red), reddish or reddish purple-lined internally on the lower surface, externally glandular-pubescent (glabrous), internally glabrous or glandular-pubescent; tube 3–7 mm long; throat 8–14 mm long, gradually expanded, the orifice 2–5 mm wide, the limb 4–10 mm wide, the lower lobes projecting-spreading, the upper lobes spreading; stamens included, the anther cells explanate, rarely open-ended navicular, fully dehiscent, 0.7–1.3 mm long, the sides glabrous, the sutures smooth or papillate, the septa heights less than one half the width of the cell walls; staminodes distal 1–2 mm with golden yellow papillae to 0.2 mm long or glabrous, the tip 0.5–0.6 mm wide, recurved. CAPSULES 5–7 mm long, 4–5 mm wide. SEEDS 1.8–2.5 mm long, black.—Gravelly, often calcareous soils in pinyon-juniper woodlands, oak and mtn. brush; n Mohave Co.; 1200–1800m (4000–6000 ft); range map: Fig. 15G; Apr–Jun; NV & UT.

Penstemon confusus is a Great Basin species, with populations in extreme nw AZ, where it may introgress with *P. utahensis*, where plants can be found with flowers intermediate between blue and red. Other places in Mohave Co., plants that would otherwise be considered *P. utahensis* have nectar guides, a character not typical for *P. utahensis*. It is tempting to consider *P. confusus* as a variety of *P. utahensis*, however, the molecular work of Wolfe *et al.* (2006) suggests that they may be more distantly related.

Penstemon dasyphyllus A. Gray (puberulent leaves) Thick-leaf beardtongue.—Perennial herbs; caudex woody. STEMS 1–5, 20–50 cm tall, often many-branched from the

bases, proximally puberulent or retrorsely puberulent, distally puberulent and glandular-pubescent. LEAVES green, linear, entire, puberulent (sometimes only along midveins and margins), the bases tapered, the apex acute; basal leaves usually absent at anthesis; basal and proximal cauline leaves 20–70 mm long, 1–9 mm wide, short-petiolate to sessile; cauline leaves 6–22 pairs, 20–130 mm long, 1–7 mm wide, sessile. THYRSES 3–30 mm long, somewhat secund, the axes glandular-pubescent, the verticillasters 4–11, the inflorescence branches 1(–2) per node, 1(–2)-flowered; proximal bracts leaflike, linear, 4–62 mm long, 1–4 mm wide, the margins entire, the apices acuminate; peduncles and pedicels mostly erect, sometimes ascending, glandular-pubescent, the peduncles to 20 mm long, the pedicels 2–35 mm long. FLOWERS: calyx lobes ovate to lanceolate, 4–8 mm long, 1.7–4 mm wide, glandular-pubescent, the margins entire, herbaceous or narrowly scarious, the apices obtuse to acute; corolla ventricose, 18–30 mm long from base to orifice, violet to lavender to purple, purple-lined internally on the lower surface, externally glandular-pubescent, internally glabrous; tube 7–9 mm long; throat abruptly expanded, the orifice 6–13 mm wide, the lower lobes projecting-spreading, the upper lobes spreading; stamens: longer pair reaching orifice, the anthers horseshoe-shaped to divergent, the cells, navicular-bulging, often misshapen, fully dehiscent or nearly so, sometimes slightly indehiscent proximally, 1.5–2.2 mm long, the sides papillate, the sutures denticulate, the teeth to 0.3 mm; staminodes included, glabrous, 0.6–1 mm wide. CAPSULES 9–15 mm long, 4–9 mm wide. SEEDS 1.7–2.6 mm long, dark brown. **2n** = 16.—Rocky ridges and gravelly slopes in desert grasslands; Cochise, Gila, Graham, Greenlee, Pima, Pinal, Santa Cruz cos.; 1000–2100 m (3600–6600 ft); range map: Fig. 15G; Apr–Sep; NM, TX; Mex.

Penstemon deaveri Crosswh. (Chester Deaver (1898-1988), founder of the Deaver Herbarium at Northern Arizona University) Deaver's or Mount Graham beardtongue.—Perennial herbs; caudex woody, not caespitose. STEMS 1–6, 10–60 cm tall, decumbent from an underground branching caudex, retrorsely puberulent to nearly glabrous. LEAVES green, not thick, entire, usually glabrous, glaucous; basal and proximal cauline leaves well-developed, crowded, 15–110 mm long, 3–22 mm wide, the blades spatulate to oblanceolate, the bases tapered, the apices rounded to obtuse; cauline leaves 3–9 pairs, 15–110 mm long, 4–16 mm wide (nearly as wide as the basal leaves), the blades elliptic, sessile, the apices obtuse to acute. THYRSES 4–26 cm long, continuous, secund or cylindric, the axes puberulent, sometimes a bit glandular-pubescent, the verticillasters 3–9, the inflorescence branches (1–)2 per node, (1–)2–4(–6)-flowered, not congested; proximal bracts leaflike, 7–55 mm long, 1–15 mm wide, the margins entire, the apices acute; peduncles and pedicels ascending to erect, puberulent, the peduncles to 10 mm, the pedicels 1–8 mm. FLOWERS: calyx lobes lanceolate, 3–5.5 mm long, 1.5–2.2 mm wide, glabrous or sparsely pubescent, the margins erose or entire, broadly scarious, the apices acuminate or mucronate; corolla ventricose, bilabiate, 9–15 mm long from base to orifice, deep to pale purple, violet-lined internally on lower surface extending into the lobes, externally glabrous or with lobes sparsely glandular, internally on the lower surface sparsely

white-hairy; tube 4–5 mm long; throat gradually expanded, not or slightly constricted at orifice, the orifice 6–9 mm wide, the lower lobes projecting-spreading, the upper lobes projecting to projecting-spreading; stamens: longer pair exserted, the anthers spreading, the cells normally open-ended navicular, fully dehiscent (variable, sometimes appearing slight indehiscent proximally, sometimes appearing nearly explanate, but then with septa heights more than one half the width of the cell walls), 1.1–1.8 mm long, the sides glabrous, papillate, or occasionally hairy near the connective, the sutures smooth to slightly papillate; staminodes exserted, distal 0.5–6 mm sparsely to moderately pilose (rarely glabrous) with yellow hairs to 0.8 mm long, the tip 0.4–1 mm wide, straight to recurved. CAPSULES 7–12 mm long, 4–8 mm wide, glabrous. SEEDS 1.7–2.8 mm long, light to dark brown, angled. [*Penstemon hallii* A. Gray var. *arizonicus* A. Gray in A. Gray *et al.*, Syn. Fl. N. Amer. 2: 263. 1878 (as *Pentstemon*), not *P. arizonicus* A. Heller 1899].—pine and subalpine forests and alpine meadows; White and Pinaleño Mtns.; Apache, Graham, Greenlee cos.; 2000–3500 m (6500–11500 ft); range map: Fig. 15H; Jun–Sep; NM.

Crosswhite (1967) raised *Penstemon deaveri* to specific level from a variety of *P. virgatus*, with which it has been confused. The bearded staminode and generally broader, elliptic cauline leaves of *P. deaveri* distinguish it from *P. virgatus*. *Penstemon deaveri* might also be confused with *P. oliganthus*. Thyrses of *P. deaveri* sometimes have scant glandular pubescence, while the thyrses of *P. oliganthus* are clearly glandular-pubescent. Also, the anther cells of *P. deaveri* are generally longer than those of *P. oliganthus*.

Penstemon discolor D. D. Keck (pale corollas, compared to *P. linarioides*) Catalina beardtongue.—Cespitose subshrubs, many-branched. STEMS 1–20+, 10–35 cm long, ascending to erect, sparsely to densely retrorsely puberulent, the hairs white, scalelike, especially distally. LEAVES cauline, semi-persistent, thick, 10–30 pairs, petiolate, 5–23 mm long, 1–1.5 mm wide, the blades narrowly oblanceolate to linear, entire, the bases tapered, the apices mucronate, the lower surface glabrous, or rarely, sparsely retrorsely hairy, the hairs white, scalelike, the upper surface densely hairy, the hairs obscuring most of the leaf surface, white, scale-like (rarely only sparsely so). THYRSES 1–15 cm long, continuous to interrupted, somewhat secund, the axes glandular-pubescent, the verticillasters 3–13, the inflorescence branches 1(–2) per node, 1(–3)-flowered; proximal bracts leaflike, linear, 2–8 mm long, 0.5–1 mm wide, the margins entire, the apices mucronate; peduncles and pedicels ascending to erect, glandular-pubescent, the peduncles to 4(–7) mm, the pedicels 1–5 mm. FLOWERS: calyx lobes ovate to lanceolate, 2–3.7 mm long, 1.2–2.2 mm wide, (calyx tube 0.2–1 mm long), glandular-pubescent, the margins entire or erose, scarious, the apices acute to mucronate; corolla tubular-funnelform, 9–11 mm long from base to orifice, lavender to violet, purple, or white, faintly to strongly reddish purple-lined internally on the lower surface, internal lower surface densely white lanate; tube 4–6 mm long; throat gradually expanded, the orifice 3.5–6 mm wide, the lobes projecting-spreading; stamens exserted, the filaments glabrous, the anthers spreading, the cells navicular, fully dehiscent, 0.8–0.9 mm long, the sides glabrous, the sutures

papillate; staminodes included or reaching orifice, distal 5–6 mm densely hairy with golden yellow hairs to 1.2 mm long, the tip 0.2–0.4 mm wide, straight to recurved. CAPSULES 5–8 mm long, 3–4 mm wide. SEEDS 1.2–1.6 mm long, black, angled to rounded.—Pinyon-juniper and oak woodlands, often in granite crevices; AZ endemic, the Dragoon, Galiuro, Santa Catalina, Santa Teresa, Winchester Mtns.; reported from the Atascosa Mtns.; Cochise, Graham, Pima, Pinal cos., 1500–2300 m (5000–7300 ft); range map: Fig. 15H; Jun–Sep.; of conservation concern.

Penstemon discolor can be confused with *P. linarioides*. Use this key:

1. Leaf blades shallowly U-shaped in cross section, the upper surface densely hairy, the hairs obscuring most of the leaf surface, the lower surface glabrous (rarely slightly retrorsely hairy).....*Penstemon discolor*
- 1' Leaf blades flat to U-shaped in cross section, both sides hairy, obscuring less than half the leaf surface, rarely glabrous *Penstemon linarioides*

Penstemon distans N. H. Holmgren (inflorescence verticillasters at distances from each other) Mt. Trumbull beardtongue.—Perennial herbs; caudex woody, not caespitose. STEMS 1–5, 18–75 cm tall, ascending to erect, proximally retrorsely puberulent, distally glandular-pubescent. LEAVES not thick, not glaucous, the margins entire or obscurely to prominently dentate (especially at the tip): basal and proximal cauline leaves crowded, 30–120 mm long, 2–14 mm wide, the blades oblanceolate, the bases tapered, petiolate, the apices obtuse (acute), retrorsely pubescent to glandular pubescent to nearly glabrous; cauline leaves 3–6 pairs, petiolate to sessile and clasping, 5–55 mm long, 1–7 mm wide, blades oblanceolate to lanceolate, the bases tapered to subcordate-clasping, the margins entire or slightly serrate at tips, the apices obtuse to acute, retrorsely pubescent to glandular pubescent. THYRSES 2–35 cm long, interrupted, cylindric, the axes glandular-pubescent, the verticillasters 3–11, the inflorescence branches 2 per node, 1–2(–3)-flowered; proximal bracts lanceolate to linear, 5–30 mm long, 1–4 mm wide, the margins entire, the apices acute; peduncles and pedicels ascending to erect, glandular-pubescent, the peduncles to 16 mm long, the pedicels 1–5 mm long. FLOWERS: calyx lobes lanceolate, 3–7 mm long, 1–2.5 mm wide, herbaceous, glandular-pubescent, the margins entire, the apices acute to obtuse; corolla ampliate-funnelform, bilabiate, bilaterally symmetric, 10–14 mm long from base to orifice, blue to violet, reddish purple-lined internally on the lower surface, externally glandular-pubescent, internally on the lower surface sparsely to moderately white- or yellow-lanate; tube 5–7 mm long; throat gradually expanded, not constricted at orifice, the orifice 4–7 mm wide, the lower lobes projecting-spreading, the upper lobes projecting-spreading to spreading; stamens included, the anthers horseshoe-shaped, the cells navicular, fully dehiscent or proximally indehiscent, 1–2 mm long, the sides papillate, the sutures entire to strongly papillate, the septa heights about the width of the cell walls; staminodes reaching orifice or barely exerted, distal 6–8 mm densely bearded with yellow-orange hairs to 1 mm long, the tip flattened, recurved. CAPSULES 6–10 mm long, 3–6 mm wide, glabrous. SEEDS 2–3.2 mm long, dark brown, angled.—Limestone gravel slopes from blackbrush scrub to pinyon-juniper woodlands; AZ

endemic, Parashant and Whitmore canyons; Mohave Co.; 1100–1600 m (3800–5400 ft); range map: Fig. 15H; Apr–Jun.; of conservation concern.

Penstemon eatonii A. Gray, (Professor Daniel Cady Eaton (1834-1895)) Eaton's or firecracker beardtongue.—Perennial herbs; caudex woody, sometimes horizontal. STEMS 1–4, 40–100 cm tall, ascending to erect, retrorsely puberulent or glabrous, not glaucous. LEAVES retrorsely puberulent or nearly glabrous, the margins entire (sometimes undulate); basal and proximal cauline leaves crowded, 35–210 mm long, 8–50 mm wide, the blades obovate to elliptic, the bases tapered, petiolate, the apices obtuse to acute; cauline leaves 3–5 pairs (rarely in whorls of three), petiolate to sessile and blunt or cordate clasping, 10–170 mm long, 8–55 mm wide, the blades ovate, lanceolate, or proximal sometimes oblanceolate, the apices acute, rarely obtuse. THYRSES (9–)12–40 cm long, secund, the axes puberulent to glabrous, the verticillasters 4–12, the inflorescence branches 2 per node, 1–2(–4)-flowered; proximal bracts lanceolate, 6–40 mm long, 1–12 mm wide, the margins entire, the apices acute to acuminate; peduncles and pedicels erect, sometimes ascending, glabrous or sparsely puberulent, the peduncles to 9 mm long, the pedicels 1–11(–26) mm long. FLOWERS: calyx lobes ovate, (2.5–)3–5(–6) mm long, 1.8–3 mm wide, glabrous, the margins usually erose, rarely entire, scarious margined, the apices acute; corolla tubular to tubular-funnelform, nearly radially symmetric, weakly bilabiate, (10–)15–26 mm long from base to orifice, red to scarlet, essentially unlined internally, externally glabrous, internally glabrous or sparsely pubescent, sinuses of the lobes often hairy, the hairs white, to 0.5 mm; tube 6–10 mm long; throat 5–7(–9) mm wide, the lobes projecting to barely spreading, broadly rounded, the lower lobes 2–3(–5) mm long, the upper lobes 4–6 mm long, all lobes about as wide as long; stamens included, reaching orifice, or exserted, the anthers horseshoe-shaped, the cells saccate, connective and proximal 1/4–1/2 indehiscent, distally dehiscent, dehiscent slits directed to the side, 1.8–2.5 mm long, usually more than 2 times longer than wide, the sides glabrous or hispidulous with tan enations up to 0.1 mm, the sutures papillate or denticulate, the teeth to 0.1 mm; staminodes well included, glabrous or distal 1–2 mm sparsely to densely pubescent with yellow hairs to 1.2 mm long, the tip 0.3–0.7 mm wide, straight. CAPSULES 9–17 mm long, 3–10 mm wide. SEEDS 2–3.2 mm long, dark brown. [*P. coccinatus* Rydb.].—Desert shrublands, pinyon-juniper woodlands, pine forests; widespread; Apache, Coconino, Gila, Greenlee, La Paz, Maricopa, Mohave, Navajo, Pima, Pinal, Yavapai cos.; 350–2400 m (1100–7900 ft); range map: Fig. 16I; Feb–Sep; Vars. 3 (3 in AZ, 2 recognized here): w US.

This treatment recognizes varieties *eatonii* and *exsertus* (which may differ enough morphologically and in range to warrant raising them to species level). Both varieties vary as to degree of hairiness, so here, I have synonymized var. *undosus* with var. *eatonii*, since var. *eatonii* has priority over var. *undosus*. My interpretation is that both varieties *eatonii* and *exsertus* can have unusual individuals that have less than full pubescence; that the amount of pubescence is not taxonomically significant, since these plants are not distinguished by geographic range, whereas the exsertion of the anthers is significant and correlates with leaf

undulation and range. Plants sometimes have only a few flowers with exserted anthers, while most of the flowers on a culm do not. If the collected plant happened to not have exserted anthers, though most of the plants in the population do, it is still *exsertus*. This may explain many of the outliers for variety *undosus* s and w of the Mogollon Rim. Variety *eatonii* predominates n and e of the Mogollon Rim. Variety *exsertus* predominates s and w of the Mogollon Rim.

1. Stamens included or reaching orifice, sometimes slightly exserted; leaves more undulate-margined *Penstemon eatonii* var. *eatonii*
 1' Stamens all exserted; leaves less undulate-margined *Penstemon eatonii* var. *exsertus*

Penstemon eatonii A. Gray var. *exsertus* (A. Nelson) C. C. Freeman. [*Penstemon exsertus* A. Nelson; *P. eatonii* subsp. *exsertus* (A. Nelson) D. D. Keck] **2n** = 16.

Penstemon eatonii var. *exsertus* is concentrated in c AZ, especially from Flagstaff s to Tucson; 550–2000 m (1800–6600 ft); Feb–Jun; Coconino, Gila, Greenlee, Maricopa, Mohave, Pima, Pinal, Yavapai cos.

Penstemon eatonii A. Gray var. *eatonii* [*Penstemon eatonii* subsp. *undosus* (M. E. Jones) D. D. Keck] **2n** = 16.

Penstemon eatonii var. *undosus* is most common in the Grand Canyon region easterly into ne AZ; 350–2400 m (1100–7900 ft); Mar–Sep.; Apache, Coconino, Gila, Maricopa, Mohave, Navajo, Yavapai cos.

Penstemon ×*crideri* A. Nelson, a putative hybrid between *P. eatonii* and *P. pseudospectabilis*, has been reported from AZ (Nelson 1936, 1938). Nelson (2076) collected *Penstemon* ×*mirus*, which is thought to be a hybrid between *P. eatonii* and *P. palmeri* (Nelson 1936, 1938) in Oak Creek Canyon, Coconino Co. *Penstemon* ×*jonesii* Pennell (included in this treatment), a putative hybrid between *P. eatonii* and *P. laevis*, is known only from Kane and Washington cos, UT (E. C. Neese and N. D. Atwood 2003) and Mohave Co., AZ (Love 2020).

Penstemon fendleri Torr. & A. Gray (Augustus Fendler (1813–1883), prominent botanist) Fendler's beardtongue.—Perennial herbs; caudex woody. STEMS 1–3, 12–45 cm tall, erect, glabrous. LEAVES thick, entire, glaucous; basal and proximal cauline leaves crowded, 15–100 mm long, 4–30 mm wide, the blades spatulate to oblanceolate, the bases tapered, petiolate, the apices rounded to acute, typically broader than cauline leaves; cauline leaves 2–7 pairs, sessile, 15–85 mm long, 8–26 mm wide, the blades lanceolate or ovate to trullate, the bases clasping to cordate-clasping, the apices obtuse to acute. THYRSES 5–30 cm long, somewhat interrupted, cylindric, the axes glabrous, the verticillasters (3–)4–13, the inflorescence branches 2 per node, 1–3(–5)-flowered; proximal bracts leaflike, trullate to ovate, 5–55 mm long, 3–15 mm wide, the margins entire, the apices acute; peduncles and pedicels ascending to erect, glabrous, the peduncles to 0–1 mm long, the pedicels 1–10 mm

long. FLOWERS: calyx lobes ovate to lanceolate, 3–6(–7) mm long, 1.4–3.5 mm wide, the margins entire or erose, glabrous or obscurely glandular distally, broadly scarious, the apices acute to caudate; corolla tubular-funnelform, bilaterally symmetric, weakly bilabiate, 12–20 mm long from base to orifice, lavender to violet or bluish, violet or reddish purple-lined internally on both surfaces, externally glabrous or obscurely glandular on limb, internally glabrous or sparsely hairy on the lower surface, the hairs flat, white; tube 6–9 mm long; throat scarcely expanded, the orifice 4–6(–9) mm wide, the lower lobes projecting or spreading, the upper lobes spreading; stamens included, the anther cells navicular, fully dehiscent, 0.8–1.4 mm long, the sides glabrous, the sutures papillate/scabrous; staminodes reaching orifice, distal 2–4 mm villous with flat golden yellow hairs to 1.2 mm long, the tip 0.8–1.6 mm wide, recurved. CAPSULES 10–15 mm long, 5–8 mm wide. SEEDS 2–4 mm long, light to dark brown, irregular-shaped, angled, alveolate. $2n = 16$.—Sandy or gravelly grasslands in se AZ; Cochise, Graham, Greenlee cos.; 1150–1600 m (3700–5350 ft); range map: Fig. 16J; Mar–Jun(–Jul); KS, NM, OK, TX; Mex.

Penstemon fendleri could be confused with *P. angustifolius*, which occurs n of the Mogollon Rim in Apache and Navajo cos. See notes after *P. angustifolius*.

Penstemon higginsii (Neese) N. H. Holmgren & N.D. Atwood (Larry Higgins [b. 1936], prominent UT botanist) Higgins' beardtongue.—Perennial herbs or subshrubs; caudex woody. STEMS 1–30+, 5–40 cm tall, decumbent to ascending or erect, basally retrorsely puberulent (sometimes sparsely), distally less so to glabrous, lacking glands. LEAVES mostly cauline, the margins papillate scabrous or hairy, the hairs pointed; proximal leaves petiolate, slightly scabrous or hairy on petiole or along margins proximally, not glaucous; cauline leaves 3–6 pairs, 10–40 mm long, 4–12 mm wide, the blades oblanceolate to spatulate or obovate, rarely linear, the bases tapered, short-petiolate to sessile, the margins papillate scabrous (entire), the apices obtuse (acute), sometimes slightly mucronate. THYRSES 2–15(–30) cm long, continuous (interrupted), second (or not), the axes glabrous or retrorsely puberulent, lacking glands, the verticillasters 2–8, the inflorescence branches 2 per node, 1(up to 4)-flowered; proximal bracts lanceolate, 10–35 mm long, 2–6 mm wide, the margins papillate scabrous (entire), the apices acute; peduncles and pedicels ascending to erect, peduncles glabrous or sparsely retrorsely puberulent, pedicels glabrous or papillate distally, the peduncles to 20 mm long, the pedicels 0.5–6 mm long. FLOWERS: calyx lobes ovate, 3–6 mm long, 1.5–2.5 mm wide, glabrous, the margins entire or erose, scarious, sometimes distinctly veined, the tips caudate to lanceolate; corolla ampliate-funnelform to ventricose, bilabiate, 9–16 mm long from base to orifice, lavender to blue or violet, unlined internally or faintly lavender-lined on the lower surface, externally and internally glabrous, lacking glands; tube 5–8 mm long; throat gradually expanded, the orifice 4–8 mm wide, the lower lobes projecting-spreading to spreading, the upper lobes projecting to spreading; stamens included or longer pair reaching orifice, the filaments glabrous, the anthers horseshoe-shaped, the cells saccate, proximally dehiscent, the distal 1/2–3/4 indehiscent, 0.9–1.6 mm long, the sides glabrous or puberulent,

the hairs white, to 0.1 mm, the sutures denticulate, the teeth to 0.2 mm; staminode included or reaching orifice, glabrous, 0.6–0.9 mm wide. CAPSULES 6–8 mm long, 2.5–4.5 mm wide. SEEDS 0.6–1.5 mm long, tan to light brown, angled. **2n** = 16. [*Penstemon leonardii* var. *higginsii* Neese].—pine-juniper woodlands; Mohave, Navajo cos.; 2000–2100 m (6500–6900 ft); range map: Fig. 16J; (May–) Jun–Jul; two locations in AZ; Black Rock Mtns. of Mohave Co. and a few kms nw of Heber in Navajo Co, where it may not have persisted; NV, UT.

Penstemon* ×*jonesii Pennell (Marcus E. Jones (1852-1934), prominent western botanist) Jones' beardtongue.—Perennial herbs; caudex woody. STEMS 1(–2), 70–110 cm tall, ascending to erect, glabrous to retrorsely pubescent, glandular. LEAVES dull green, glabrous to pubescent, the margins entire or undulate; basal and proximal cauline leaves crowded, 40–100 mm long, 5–30 mm wide, the blades oblanceolate to elliptic, the bases tapered, petiolate, the apices rounded; cauline leaves 4–6 pairs, 60–100 mm long, 15–25 mm wide, the blades oblanceolate, elliptic, or lanceolate, the bases blunt or cordate-clasping, sessile, the apices obtuse to acute. THYRSES 25–50 cm long, continuous, secund, the axes glabrous or glandular pubescent; verticillasters 12–20, the inflorescence branches 2 per node, 1–5-flowered; proximal bracts leaflike, lanceolate to ovate, 25–35 mm long, 10–15 mm wide, the margins entire, the apices acute or mucronate; peduncles and pedicels ascending to erect, glabrous to pubescent, glandular, the peduncles to 4 mm long, the pedicels 2–14 mm long. FLOWERS: calyx lobes ovate to lanceolate, 4–6 mm long, 2–3.2 mm wide, glabrous or pubescent and glandular, the margins slightly scarious, the apices acute or mucronate; corolla ventricose, bilabiate, 17–27 mm long from the base to the orifice, blue to violet to reddish-magenta to pinkish, colors variable within a population, reddish violet-lined internally on the lower surface, externally and internally glabrous to slightly glandular; tube 3–7 mm long; throat abruptly expanded, the orifice not constricted, 4–10 mm wide, the lobes projecting-spreading; stamens: longer pair reaching orifice or exserted, the anthers horseshoe-shaped, the cells scoop-shaped, straight or slightly curved, but not sigmoid, connective and proximal 1/5–1/3 indehiscent, dehiscent distally, dehiscent slits directed up and away from the filament, 2.2–2.6 mm long, the sides glabrous or papillate, the sutures denticulate, the teeth to 0.1 mm; staminodes included or exserted, distal 2–3 mm densely to sparsely pilose with yellow hairs to 0.8(–1) mm long, the tip, 0.5 mm wide, straight to recurved. CAPSULES 10–12 mm long, slightly glandular.—Sandy soil in pinon-juniper to oak ponderosa pine woodlands; Mohave Co.; 1550–1800 m (5100–5900 ft); range map: Fig. 16J; Apr–Jun; along the UT border w of Fredonia in Mohave Co., sw UT.

Penstemon ×*jonesii* Pennell, a putative hybrid between *P. eatonii* and *P. laevis*, is known only from Kane and Washington cos, UT (E. C. Neese and N. D. Atwood 2003) and Mohave Co., AZ (Love 2020). See Crump *et al.* (2020) for a discussion of the relationship between *Penstemon eatonii* and *P. laevis*. *Penstemon leiophyllus* would key out here; it occurs just over the border in UT and is likely for AZ. The following couplet separates *P. leiophyllus* from *P. ×jonesii*.

1. Anther cells 1.2–1.8 mm long *Penstemon leiophyllus*
 1' Anther cells 2–2.6 mm long *Penstemon ×jonesii*

Penstemon laevis Pennell (smooth) Southwestern beardtongue.—Perennial herbs; caudex woody. STEMS 1–2(–3), 20–90 cm tall, ascending to erect, glabrous, slightly glaucous. LEAVES dull to bright green, sometimes with a purple cast, somewhat leathery, glabrous, somewhat glaucous, the margins entire or undulate; basal and proximal cauline leaves crowded, 30–120(–150) mm long, 8–30 mm wide, the blades oblanceolate to elliptic, the bases tapered, petiolate, the apices rounded; cauline leaves 2–6 pairs, 5–120 mm long, 5–20 mm wide, the blades oblanceolate, elliptic, or lanceolate, the bases sessile, clasping, the apices obtuse to acute. THYRSES 8–48 cm long, continuous, secund, the axes glabrous; verticillasters 5–16, the inflorescence branches (1–)2 per node, 1–5-flowered; proximal bracts leaflike, lanceolate to ovate, 5–65 mm long, 2–15 mm wide, the margins entire, the apices acute or mucronate; peduncles and pedicels ascending to erect, glabrous, the peduncles to 7 mm long, the pedicels 1–11 mm long. FLOWERS: calyx lobes ovate to lanceolate, 3–6(–10) mm long, 1.5–3.4 mm wide, glabrous, the margins erose, scarious, the apices acuminate to caudate; corolla ventricose, bilabiate, 18–23 mm long from base to orifice, blue to violet to reddish-magenta, colors consistent within a population, reddish violet-lined internally on the lower surface, externally and internally glabrous; tube 7–11 mm long; throat abruptly expanded, the orifice constricted or not, 7–12 mm wide, the lower lobes spreading, the upper lobes projecting-spreading; stamens: longer pair reaching orifice or exserted, the anthers horseshoe-shaped to divergent, often somewhat erect or spreading to the side, the cells scoop-shaped, often a bit sigmoid, connective and proximal $\frac{1}{4}$ indehiscent, dehiscent distally, 2–2.2(–2.5) mm long, the sides glabrous or slightly papillate, the sutures denticulate, the teeth to 0.1 mm; staminodes included or exserted, distal 2–4 mm densely to sparsely pilose with yellow hairs to 0.8(–1) mm long, the tip 0.4–0.6(–0.9) mm wide, straight to recurved. CAPSULES 7–10 mm long, 4–6 mm wide, slightly glandular. SEEDS 1.2–2.5 mm long, dark brown, angled.—Sandy soil in pinon-juniper woodlands up to subalpine forests; along the UT border w of the Colo. River and s onto the Kaibab Plateau; Coconino and Mohave cos.; 1600–2650 m (5200–8700 ft); range map: Fig. 16K; May–Sep, sw UT.

Penstemon lanceolatus Benth. (lanceolate leaves) Lance-leaf beardtongue.—Perennial herbs; caudex woody. STEMS 1–5, 24–75 cm tall, densely retrorsely puberulent to puberulent, glandular-pubescent distally. LEAVES dull green, retrorsely puberulent, the apex abruptly acute to rounded, basal usually absent at anthesis; basal and proximal cauline leaves 40–100 mm long, 1–5 mm wide, the blade linear to lanceolate, the base tapered, petiolate, the margins entire; cauline leaves 7–10 pairs, 20–100 mm long, 1–5 mm wide, blade linear, base tapered to truncate, short-petiolate to sessile. THYRSES 7–30 mm long, somewhat secund, axes glandular-pubescent, verticillasters 4–9, the inflorescence branches 1(–2) per node, 1–2-flowered; proximal bracts leaflike, lanceolate to linear, 5–20, 1–3 mm, the margins entire, the

apex abruptly acute to rounded; peduncles and pedicels ascending to erect, glandular-pubescent, the peduncles to 15 mm, the pedicels 4–11 mm. FLOWERS: calyx lobes ovate to lanceolate, 4–7 mm long, 2–4 mm wide, glandular-pubescent, the margins entire, herbaceous or narrowly scarious, the apex rounded to acute; corolla tubular-funnelform, 20–27 mm long from base to orifice, red, unlined internally, externally sparsely glandular-pubescent, internal lower limb glandular; tube 6–10 mm long; throat gradually expanded, the orifice 5–9 mm wide, the lower lobes projecting-spreading or spreading, the upper lobes projecting; stamens exerted (hidden by galeate upper lobes), anthers horseshoe shaped to divergent, the cells navicular-bulging, often misshapen, connective and proximal portion dehiscent to well more than 1/2 of length, the distal portion indehiscent, or fully dehiscent, 1.5–2.2 mm long, the sutures denticulate, the teeth to 0.2 mm, the sides papillate; staminodes included, glabrous, the tip 0.3–0.4 mm wide. CAPSULES 9–16 mm long, 5–8 mm wide. SEEDS 1.9–3 mm, brown to dark brown. $2n = 16$.—Rocky or gravelly slopes, pine woodlands, thorn scrub, desert grasslands; mostly Chiricahua and Pinaleno Mtns., a historic collection (*F. S. Crosswhite 1966*) from the Santa Rita Mtns. could be in either Pima or Santa Cruz co.; Cochise, Graham, Greenlee, cos (Santa Cruz Co record at NY [*Annable 2388*] is *P. parryi*), 1000–1950 m (3200–6400 ft); range map: Fig. 16K; Mar–Aug; NM, TX; Mex.

Anderson *et al.* (2007) synonymized *Penstemon ramosus* with *P. lanceolatus*. Specimens in herbaria are determined as both *P. lanceolatus* and *P. ramosus*.

Penstemon lentus Pennell (pliant) Abajo beardtongue.—Perennial herbs; caudex woody. STEMS 1–6, 14–40(–60) cm tall, ascending to erect, glabrous. LEAVES thick, glabrous, glaucous, entire; basal and proximal cauline leaves crowded, 20–75(–110) mm long, 5–40 mm wide, petiolate to sessile, the blades spatulate to oblanceolate, the bases blunt to tapered, the apices rounded; cauline leaves 2–4 pairs, 10–66 mm long, 7–30 mm wide, the blades ovate to lanceolate, sessile, clasping or cordate-clasping, the apices rounded to acute. THYRSES 5–26 cm long, congested to interrupted, usually secund, sometimes cylindric, the axes glabrous, the verticillasters 4–12, the inflorescence branches (1–)2 per node, 1–3(–6)-flowered; proximal bracts ovate to lanceolate, (3–)7–70 mm long, (1–)2–30 mm wide, the margins entire, the apices acute; peduncles and pedicels ascending to erect, glabrous, the peduncles to 30 mm long, the pedicels 1–9 mm long. FLOWERS: calyx lobes ovate to lanceolate, 5–7 mm long, 1.7–3.7 mm wide, glabrous, the margins erose, broadly scarious, scarious portions tinged blue or violet, the apices acute to acuminate or short-caudate; corolla tubular-funnelform, weakly bilabiate, 11–16 mm long from base to orifice, lavender to violet, blue, pinkish blue, or white, unlined internally or reddish violet-lined on the lower surface, externally glabrous, internal lower surface sparsely white-villous or glabrous; tube 5–10 mm long; throat gradually expanded, the orifice 4–8 mm wide, the lower lobes projecting, the upper lobes projecting or spreading; stamens included or longer pair reaching orifice, the anthers spreading, the cells open-ended navicular, fully dehiscent, 1.1–1.3 mm long, the sides glabrous, the sutures papillate; staminodes reaching orifice or slightly exerted, distal 2–3(–6) mm

sparsely to densely villous mostly along the margins with yellowish hairs to 0.8 mm long, the tip 0.6–1 mm wide, strongly recurved. CAPSULES 7–12 mm long, 5–8 mm wide, glabrous to slightly papillate glandular. SEEDS 2–5 mm long, dark brown, angled.—2 vars.—sagebrush shrublands, pinyon-juniper and oak woodlands, ponderosa pine forests; Apache, Navajo cos.; 1800–2600 m (5900–8550 ft); range map: Fig. 16K; May–Jul; CO, NM, UT.

1. Corollas lavender to violet, blue, pinkish blue *Penstemon lentus* var. *lentus*
 1' Corollas white *Penstemon lentus* var. *albiflorus*

Penstemon lentus Pennell var. *lentus* --pine woodlands; Apache, Navajo cos. 1800–3000 m (5900–8700 ft); May; UT.

Penstemon lentus Pennell var. *albiflorus* (D.D. Keck) Reveal --pine woodlands; Apache Co. 2300 m (7550 ft); May; UT. Only known in AZ from the Chuska Mtns. (*Clifford 03-411*).

Penstemon lentus and *P. pachyphyllus* are allopatric but often confused. They are similar enough to be sister taxa, but molecular data (Wessinger *et al.* 2016, Wessinger *et al.* 2019, Wolfe 2021) show that they are not. The following key may help to differentiate them.

1. Inflorescence branches 1–3(–6)-flowered; corolla 11–16 mm long from base to orifice, the orifice 4–8 mm wide; staminode with distal 2–3(–6) mm hairy, the hairs to 0.8 mm long, the tip 0.6–1 mm wide; Apache, Navajo cos..... *Penstemon lentus*
 1' Inflorescence branches (1–)3–9-flowered; corolla 15–25 mm long from base to orifice, the orifice 5–12 mm wide; staminode with distal 4–9 mm hairy, the hairs to 1.5(–2) mm, the tip (0.2–)0.5–2 mm wide; Coconino, Mohave cos..... *Penstemon pachyphyllus*

See also note following *Penstemon angustifolius*.

Penstemon linarioides A. Gray (like *Linaria*) Toad-flax beardtongue.—Cespitose subshrubs, many-branched at or below ground level. STEMS 1–30+, 5–50 cm long, ascending to erect, retrorsely puberulent, the hairs white, either cylindric and wiry, or flattened and ribbon-like. LEAVES: cauline, 6–20 pairs, 4–32 mm long, 0.6–3.5 mm wide, the blades mostly linear to lanceolate, sometimes oblanceolate, the bases tapered to truncate, petiolate to sessile, the margins entire, the apices mucronate, the surfaces hairy or glabrous, when hairy, the hairs either cylindric and wiry or flattened and ribbon-like, spreading to retrorse, obscuring less than half of the leaf surface, the upper and lower surfaces about equally hairy. THYRSES 3–20 cm long, continuous to interrupted, secund, the axes puberulent or glandular-pubescent, the verticillasters 3–12, the inflorescence branches 1(–2) per node, 1–2(–5)-flowered; proximal bracts leaflike, 5–25 mm long, 0.7–1 mm wide, entire, the apices slightly hard-tipped; peduncles and pedicels ascending to erect, puberulent or glandular-pubescent, the peduncles to 7 mm long, the pedicels 1–7 mm long. FLOWERS: calyx lobes ovate, 3–8 mm long, 1.2–3 mm wide, glandular-

pubescent, the margins broad, hyaline, erose, the hyaline portions extending about 2/3 from base to tip, the apices acute to acuminate or short caudate; corolla funnelform to slightly to strongly ventricose-ampliate, 8–15(–17) mm long from base to orifice, blue-pink-lavender, internal lower surface lined, white- or yellowish villous, the hairs passing onto limb, the hairs reddish purple; tube 5–7 mm long; throat abruptly expanded, the orifice 5–10 mm wide, all lobes spreading; stamens: longer pair reaching orifice or slightly exserted, the filaments glabrous, the anthers spreading, the cells navicular, fully dehiscent, 0.9–1.3 mm long, the sides and sutures papillate; staminodes exserted, distal 1–5 mm densely hairy with yellow to golden yellow hairs to 1.2 mm long, sparsely hairy 1–4 mm below the distal tuft, the staminode tip 0.3–0.5 mm wide, straight to recurved. CAPSULES 4–9 mm long, 3–5 mm wide. SEEDS 0.9–2.4 mm long, brown to black, angled.—desert scrub to pine woodlands and mixed conifer forest; all cos. except Yuma; 1000–3000 m (3300–7900 ft); range map: Fig. 16L.—4 vars., all in AZ.—a widespread and highly variable species of the sw US.

D. D. Keck (1937) recognized seven subspecies on the basis of habit, pubescence, leaf shape, and staminode bearding. Freeman (2019) recognized four varieties. I recognize three for AZ. According to Kearney and Peebles (1960) and Freeman (2019), *Penstemon linarioides* var. *macguirei* (defined as having broader than typical leaves for the species) is local in Gila River Valley (Greenlee Co.), however specimens with leaves broader than typical have been found in Apache, Graham, Navajo, and Yavapai cos. My sense is that plants with anomalous wide leaves can be found throughout the range of the species and that they are not taxonomically significant.

1. Leaf blades glabrous or puberulent, when hairy, the hairs cylindric, wire-shaped..... *Penstemon linarioides* var. *sileri*
- 1' Leaf blades retrorsely puberulent, the hairs scale-like
 2. Staminodes with distal 3–5 mm hairs to 1.2 mm long, not so sharply differentiated from the more proximal shorter and often sparser hairs..... *Penstemon linarioides* var. *linarioides*
 - 2' Staminodes with distal 1 mm hairs to 0.8 mm long, sharply differentiated from the more proximal shorter and often sparser hairs..... *Penstemon linarioides* var. *coloradoensis*

Penstemon linarioides A. Gray var. ***coloradoensis*** (A. Nelson) C. C. Freeman. (range in, and proximal to, the state of Colorado) Colorado beardtongue.—[*Penstemon coloradoensis* A. Nelson *P. linarioides* subsp. *coloradoensis* (A. Nelson) D. D. Keck].—pine and oak woodlands to mixed conifer forest; Apache, Coconino, Navajo cos. 1800–3000 m (5900–9900 ft); May–Aug; CO, NM.

Staminode hair patterns of vars. *coloradoensis* and *linarioides* vary from those with a well defined apical tuft and much sparser and shorter hairs below the tuft for several mm with all hairs less than 0.8 mm long to those with hairs more uniform from the tip down the shaft to the glabrous portion and all less than 0.6 mm long to ones with longer hairs in the tuft (to 1.2 mm). I have also seen plants where the staminode hairs are those of var. *coloradoensis* in one flower and var. *linarioides* in another. In summary, I see a full range of staminode hair arrangements, with those of var. *coloradoensis* in the ne portion of AZ.

Penstemon linarioides A. Gray var. ***linarioides***. Toad-flax beardtongue.—[*Penstemon linarioides* subsp. *compactifolius* D. D. Keck].—rocky slopes in sagebrush shrublands and pinyon-juniper woodlands to mixed conifer forest; Apache, Cochise, Coconino, Gila, Graham, Greenlee, Maricopa, Navajo, Pima, Pinal, Santa Cruz, Yavapai cos.; 1300–3000 m (4200–9900 ft); May–Oct; NM.

D. D. Keck (1937) named plants generally similar to var. *linarioides* but with more compact, heathlike leaves, ascending stems, and decumbent rootstocks as subsp. *compactifolius*, stating that it was limited to the vicinity of Flagstaff and that it intergraded with both subsp. *sileri* and var. *viridis* D. D. Keck. Plants with *compactifolius*-like leaves are encountered elsewhere in the species' range. See notes with vars. *coloradoensis* and *sileri*.

Penstemon linarioides A. Gray var. ***sileri*** A. Gray (Andrew Lafayette Siler (1824–1898), early Mormon pioneer in s UT) Siler's beardtongue.—[*Penstemon linarioides* subsp. *sileri* (A. Gray) D. D. Keck; *P. linarioides* var. *viridis* D. D. Keck].—sandy to clay soils in sagebrush shrublands, oak or oak-juniper woodlands, and pine forests; all cos except Yuma Co.; Apr–Oct; 1000–2600 m (3000–8400 ft); NV, UT.

Variety *sileri* is relatively common in n AZ, s NV, and sw UT. Plants with glabrous or nearly glabrous leaves from n AZ and s UT have been referred to var. *viridis*. As noted by N. H. Holmgren (1984), such forms occur sporadically through much of the range of var. *sileri*, therefore taxonomic recognition of var. *viridis* is unwarranted. Some specimens included in var. *sileri* from n AZ, especially from the Kaibab Plateau, have the habit of subsp. *compactifolius* (included here in var. *linarioides*) with the leaf pubescence of var. *sileri* (or var. *viridis*), so are classified with var. *sileri*.

Penstemon navajoa N. H. Holmgren (from Navajo) Navajo Mountain beardtongue.—Perennial herbs; caudex woody. STEMS 1–8, 10–65 cm long, decumbent from an underground branching caudex, sometimes spread out flat on the ground, retrorsely puberulent to glabrous. LEAVES green, not glaucous, not thick, retrorsely puberulent to nearly glabrous, papillate, the margins entire; basal and proximal cauline leaves well-developed, sometimes early deciduous, 12–80 mm long, 4–12 mm wide, the blades spatulate to oblanceolate, the bases tapered, the apices rounded to obtuse; cauline leaves 2–5 pairs, 30–65 mm long, 1–6 mm wide, the blades linear to oblanceolate, sessile, the apices rounded to acute. THYRSES 8–25 cm long, continuous, secund or cylindric, the axes glabrous or slightly puberulent, the verticillasters 4–10(-14), overlapping as much as 1/3 of their length, the inflorescence branches 1–2 per node, the branches 1–3-flowered, not congested; proximal bracts leaflike, 5–70 mm long, 0.7–2 mm wide, the margins entire, the apices acute; peduncles and pedicels ascending to erect, glabrous or puberulent, the peduncles to 25 mm, the pedicels 1–11 mm long. FLOWERS: calyx lobes ovate to broadly lanceolate, the lobes 2.4–4 mm long, 2–3 mm wide, glabrous, the margins entire, scarious, the apices acuminate or mucronate; corollas ventricose, 10–17 mm long from base to orifice, bilabiate, blue to lavender, violet-lined internally on lower surface extending onto the lobes, externally glabrous, internal lower surface sparsely white-hairy (glabrous); tube 5–7 mm long; throat gradually expanded, not or slightly constricted at orifice, the orifice 5–10

mm wide, the lower lobes projecting-spreading, the upper lobes projecting to projecting-spreading; stamens: longer pair exserted, the anther cells spreading, the cells scoop-shaped, proximally shortly indehiscent, distally dehiscent, the longest cells 1.2–1.7 mm long, the sides long hairy to glabrous, the hairs (when present) 1.2–2 mm long, the sutures papillate, the papillae 0.05–0.1 mm long, sharp-pointed, the septum clearly less than the width of the cell walls; staminodes exserted, glabrous, the tip 0.5–1.2 mm wide, straight. CAPSULES 6–13 mm long, 2.5–6.5 mm wide, glabrous. SEEDS 2.5 mm long, light to dark brown, angled.—pine and subalpine forests; endemic to Navajo Mtn.; San Juan Co., UT; 2200–3200 m (7200–10400 ft); no range map; Jun–Aug.

Penstemon navajoa occurs 1400 m n of the AZ border on Navajo Mtn. in s San Juan Co, UT. *Penstemon navajoa* specimens from further n in UT are misidentified, being more similar to what we have called our native AZ *P. strictus*. Robert Johnson (BRY), Mikel Stevens, and I spent part of a day looking for *Penstemon navajoa* in AZ, on the south slopes of Navajo Mtn. s of War God Spring. As we headed south toward the AZ border, the habitat changed from ponderosa pine where we found *P. navajoa* to pinon juniper woodland, habitat where *P. navajoa* does not occur. *Penstemon navajoa* is unlikely to be found in AZ, but it seems worthwhile to consider it and its nearby look-a-likes here, especially as plants have been determined incorrectly as *P. navajoa* from areas far from Navajo Mtn.

Penstemon navajoa can appear similar to several species we have in AZ, including *P. virgatus*, *P. strictus*, *P. strictiformis*, and *P. comarrhenus*, but is usually more delicate than these. A character that can be useful is the number of stem leaf pairs, 2–5 in *P. navajoa*, 5–8 in *P. comarrhenus*, 4–10 in *P. strictus*, 5–11 in *P. virgatus*, and 4–6 in *P. strictiformis*. *Penstemon strictiformis* is easily discernable from *P. navajoa* based on calyx lobe lengths, 2–4 mm in *P. navajoa*, 5–7.5 mm in *P. strictiformis*. *Penstemon navajoa* has partially indehiscent scoop-shaped anther cells, while *P. virgatus*, *P. pseudoputus*, and *P. putus* have fully dehiscent navicular anther cells.

Penstemon nudiflorus A. Gray, (glabrous corolla) Flagstaff beardtongue.—Perennial herbs; caudex woody. STEMS 1–2(–4), (35–)55–100 cm tall, erect, glabrous, glaucous. LEAVES thick, leathery, glabrous, glaucous, entire; basal and proximal cauline leaves crowded, 25–110 mm long, (4–)8–15(–27) mm wide, the blades ovate to elliptic or lanceolate, the bases tapered, petiolate, the apices obtuse to acute; cauline leaves 3–6 pairs, (5–)15–105 mm long, (1–)2–15(–30) mm wide, the blades lanceolate, the bases tapered to clasping, sessile, the apices acute to acuminate. THYRSES 8–55 cm long, expanded, interrupted, cylindric, the axes glabrous, the verticillasters 5–13, the inflorescence branches (1–)2 per node, 1–2(–3)-flowered; proximal bracts lanceolate to subulate, 4–15 mm long, 1–3 mm wide, the margins entire, the apices acute to acuminate; peduncles and pedicels spreading to ascending, glabrous, the peduncles to 50 mm long, the pedicels 4–20 mm long. FLOWERS: calyx lobes ovate to lanceolate, 4–5.8 mm long, 2.5–3.2 mm wide, glabrous, the margins entire or erose, narrowly scarious, the apices obtuse to acute; corollas ventricose-ampliate, bilabiate, (12–)15–25 mm

long from base to orifice, pale blue to lavender, internally reddish purple-lined, externally glabrous, the internal lower surface white-hairy; tube 6–9 mm long; throat gradually to abruptly expanded, not constricted at orifice, the orifice 7–11 mm wide, the lower lobes spreading, the upper lobes projecting-spreading; stamens: longer pair exserted, the anthers spreading, the cells open-ended navicular, fully dehiscent, 1.7–2.3 mm long, the sides glabrous to papillate, the sutures denticulate, the teeth to 0.1 mm; staminodes reaching orifice or exserted, distal 2–13 mm sparsely hairy with flat, white hairs to 1.5 mm long, the tip 0.5–1 mm wide, straight. CAPSULES 8–14 mm long, 5–8 mm wide, glabrous. SEEDS 3 mm long, brown, angled.—mostly volcanic soil in pine woodlands; Coconino, Gila, Navajo, Yavapai cos.; 1500–2300 m (5000–7500 ft); range map: Fig. 17M; May–Sep; AZ endemic.

Penstemon oliganthus Wooton & Standl. (few-flowered) Apache beardtongue.—Perennial herbs; caudex woody, not caespitose. STEMS 1–7, decumbent to erect, 7–45 cm tall, proximally glabrous or retrorsely puberulent, distally glandular-pubescent, not glaucous. LEAVES not thick, not glaucous, petiolate, the margins entire; basal and proximal cauline leaves, 15–80 mm long, 4–15 mm wide, the blades spatulate to elliptic, the bases tapered, the apices usually rounded, glabrous or short-hairy; cauline leaves 2–6 pairs, sessile, 7–70 mm long, 1–15 mm wide, the blades oblanceolate to lanceolate, the bases tapered to clasping, rarely obscurely denticulate distally, the apices rounded, glandular-pubescent. THYRSES 2–24 cm long, interrupted, the axes glandular-pubescent, the verticillasters (2–)3–7, the inflorescence branches (1–)2 per node, 1–10-flowered; proximal bracts leaflike, lanceolate to linear, 7–38 mm long, 1–7 mm wide, the margins entire, acuminate, ultimate apices blunt; peduncles and pedicels erect, glandular-pubescent, the peduncles to 34 mm long, the pedicels 1–18 mm long. FLOWERS: calyx lobes lanceolate, 2.8–6 mm long, 0.9–2 mm wide, glandular-pubescent, the margins erose to entire, scarious, the apices acute; corolla tubular to tubular-funnelform, bilabiate, nearly personate, 8–13 mm long from base to orifice, blue, reddish purple-lined internally on the lower surface, externally glandular-pubescent, internally on the lower surface sparsely to moderately white-hairy; tube 5–7 mm long; throat scarcely expanded, the orifice 2.5–7 mm wide, the lower lobes projecting, the upper lobes spreading to reflexed; stamens: longer pair included or exserted, the anthers spreading, the cells navicular, proximally dehiscent, distally indehiscent, or fully dehiscent, 0.7–1.2 mm long, the sides and sutures papillate; staminodes included or slightly exserted, distal 3–6 mm densely pilose with golden hairs to 1 mm long, the tip 0.3–0.4 mm wide, straight to slightly recurved. CAPSULES 5–9 mm long, 3–4.5 mm wide, glabrous. SEEDS 0.5–1.2 mm long, tan to dark brown, angled. **2n** = 16. [*Penstemon pseudoparvus* Crosswh.].—Wet or dry montane meadows in pine and spruce-fir forests; Apache, Coconino, Greenlee, Navajo, Yavapai cos; 2050–3100 m (6700–10,200 ft); range map: Fig. 17N; Jul–Sep; NM.

In AZ, *Penstemon oliganthus* mostly occurs in the White Mtns. of ec AZ, with scattered locations between the Mogollon Rim and Flagstaff, and on Mingus Mtn.; NM.

Penstemon ophianthus Pennell (snake-like flowers, possibly a reference to the curved, fuzzy staminode) Arizona beardtongue.—Perennial herbs; caudex woody. STEMS 1–10, 8–50 cm tall, ascending to erect, proximally retrorsely puberulent, sometimes also sparsely glandular-pubescent proximally and distally, not glaucous. LEAVES glabrous or sparsely puberulent, the bases tapered, the margins entire to sinuate-dentate; basal and proximal cauline leaves crowded, 16–100 mm long, 1–12 mm wide, petiolate, the blades narrowly oblanceolate, the apices obtuse to acute; cauline leaves 2–4 pairs, 15–90 mm long, 2–12 mm wide, short-petiolate to sessile, the blades oblanceolate to linear, the margins entire, rarely sinuate dentate or dentate, the apices acute to obtuse. THYRSES 2–35 cm long, interrupted to continuous, secund, the axes glandular-pubescent, the verticillasters 4–9, the inflorescence branches (1–)2 per node, 1–8-flowered; proximal bracts leaf-like, lanceolate, 12–50 mm long, 1.5–8 mm wide, the margins entire, rarely sinuate-dentate to dentate, the apices acute, glabrous to glandular puberulent; peduncles and pedicels ascending to erect, glandular-pubescent, the peduncles to 30 mm long, the pedicels 1–10 mm long. FLOWERS: calyx lobes lanceolate, 5–9 mm long, 1.3–2.6 mm wide, glandular-pubescent externally, less so to glabrous internally, the margins entire, narrowly scarious, the apices acuminate, green, often with purple; corolla ventricose-ampliate, bilaterally symmetric, strongly bilabiate, 10–15(–17) mm long from base to orifice, purple, rarely white, deep violet-lined internally (and sometimes externally) on both surfaces, often passing onto limb, the tube 5–8 mm long, the throat abruptly expanded, not constricted at orifice, the orifice 7–12 mm wide, the lower lobes spreading or reflexed, the upper lobes projecting-spreading, externally glandular-pubescent, internal lower surface at least sparsely glandular-pubescent, lower surface of the orifice hairy, the hairs flat, long; stamens included to longer pair exserted, the anther cells fully dehiscent, explanate, 0.8–1.4 mm long, the sutures smooth, septa heights less than one half the width of the cell walls; staminodes exserted, 11–13 mm long, distal 8–9 mm densely hairy with yellow hairs to 2.4 mm long, the medial hairs shorter, stiffer, and retrorse, the tip 0.4–0.9 mm wide, recurved. CAPSULES 6–12 mm long, 5–8 mm wide, glabrous. SEEDS 2.2–4.2 mm long, black, angled. $2n = 16$. [*Penstemon pilosigulatus* A. Nelson, *Penstemon jamesii* Benth. subsp. *ophianthus* (Pennell) D. D. Keck].—Sagebrush shrublands, pinyon-juniper and oak woodlands, and ponderosa pine forests; Apache, Coconino, Mohave, Navajo, Yavapai cos.; 1200–2450 m (4100–8100 ft); range map: Fig. 17O; May–Sep.; CO, NM, UT.

Penstemon pachyphyllus A. Gray ex Rydb. (thick leaves) Thick-leaf beardtongue.—Perennial herbs; caudex woody. STEMS 1–3(–10), (10–)15–85 cm tall, ascending to erect, glabrous, dull green. LEAVES thick, glabrous, glaucous, entire; basal and proximal cauline leaves crowded, 18–180 mm long, 5–45 mm wide, equally broad from base to inflorescence, the blades spatulate to elliptic, the bases tapered, petiolate, the apices rounded to acute; cauline leaves 2–5(–6) pairs, 5–90 mm long, 7–32 mm wide, the blades ovate or lanceolate, the bases clasping to cordate-clasping, sessile, the apices acute to rounded. THYRSES 5–45 cm long, interrupted to continuous, congested, cylindric, the axes glabrous, the verticillasters 3–12, the

inflorescence branches (1–)2 per node, (1–)3–9-flowered; proximal bracts leaf-like, ovate to lanceolate, 5–50 mm long, 7–28 mm wide, the margins entire, the apices acute; peduncles and pedicels ascending to erect, glabrous, the peduncles to 12(–26) mm long, the pedicels 1–15 mm long. FLOWERS: calyx lobes ovate to lanceolate, 3–7 mm long, 1.8–4 mm wide, glabrous, the margins erose or entire, broadly scarious, the apices acute to acuminate or caudate; corolla tubular-funnelform to weakly ventricose, bilaterally symmetric, weakly bilabiate, 15–25 mm long, blue to violet, unlined internally or reddish violet-lined on the lower surface, externally glabrous, internally glabrous or sparsely white-villous on the lower surface; tube 4–7 mm long; throat gradually expanded, the orifice 5–12 mm wide, the lobes spreading; stamens included or longer pair exserted, the anthers spreading, the cells open-ended navicular, fully dehiscent, (0.7–)1.2–1.5 mm long, the sides and sutures papillate; staminodes reaching orifice or slightly exserted, distal 4–9 mm densely villous with yellow to golden yellow hairs to 1.5(–2) mm long, the tip (0.2–)0.5–2 mm wide, recurved, slightly notched. CAPSULES 8–12 mm long, 4–7 mm wide. SEEDS 2–4 mm long, reddish to dark brown, angled.—Sandy to gravelly sagebrush shrubland to pine woodlands; Coconino, Mohave cos.; 1130–2350 m (3700–7800 ft); range map: Fig. 17N; May–Jul; CO, ID, NV, UT, WY. [*Penstemon nitidus* Douglas ex Benth. var. *major* Benth.].—2 vars., apparently only var. *congestus* in AZ.

Penstemon pachyphyllus A. Gray ex Rydb. var. ***congestus*** (M. E. Jones) N. H. Holmgren, [*Penstemon acuminatus* Douglas ex Lindl. var. *congestus* M. E. Jones; *P. pachyphyllus* subsp. *congestus* (M. E. Jones) D. D. Keck; NV, UT.

See notes with *Penstemon lentus*.

Penstemon palmeri A. Gray (Edward Palmer (1829-1911), prominent botanist) Palmer's or scented beardtongue.—Perennial herbs; caudex woody. STEMS 1–50+, 20–140(–210) cm tall, ascending to erect, glaucous. LEAVES thick, leathery, glaucous, the margins coarsely dentate (rarely entire), the teeth tips hardened; basal and proximal cauline leaves crowded, (20–)55–120(–145) mm long, (5–)25–60 mm wide, the blades ovate, the bases tapered, petiolate, the apices obtuse to acute; cauline leaves 5–8 pairs, 25–130(–145) mm long, 7–50(–90) mm wide, the blades ovate to broadly lanceolate, the distal leaves connate-perfoliate or sessile, the apices acute. THYRSES 7–63 cm long, usually interrupted, sometimes branched, secund, the axes glandular-pubescent or glabrous, the verticillasters (4–)7–17, the inflorescence branches 2 per node, (1–)2–3(–5)-flowered; proximal bracts leaflike, lanceolate, 5–25 mm long, 2–25 mm wide, usually entire, the apices acute, glandular-pubescent or glabrous; peduncles and pedicels ascending to erect, glandular-pubescent or glabrous, the peduncles to 20 mm long, the pedicels 3–23 mm long. FLOWERS often paired, calyx lobes ovate, (3.4–)4.2–6(–7.5) mm long, 1.9–3.6 mm wide, glandular-pubescent or glabrous, the margins entire or erose, broadly scarious, the apices obtuse to acute; corolla ventricose-ampliate, strongly bilabiate, 12–17(–27) mm long from base to orifice, white to deep pink or rose (purple), reddish purple-lined internally on the lower surface extending onto lobes of limb,

internally and externally glandular-pubescent, also often sparsely white hairy on the lower surface with flat hairs; tube 4–8 mm long; throat abruptly and broadly expanded, often constricted at orifice, the orifice 10–20(–24) mm wide, the lower lobes spreading or reflexed, about 9 mm long by 10 mm wide, lanate to glabrous, the upper lobes projecting-spreading, about 4 mm long by 8 mm wide; stamens included or longer pair reaching orifice, the filaments of the shorter pair densely glandular-puberulent at bases, the filaments of the longer pair sparsely glandular puberulent, the anthers spreading, the cells explanate or navicular, fully dehiscent, 1.6–2.4 mm long, glabrous or papillate, the sutures smooth, the septa heights less than one half the width of the cell walls; staminodes exerted, proximal 6–8 mm glandular-puberulent, distal 8–10 mm and especially the tip, moderately to densely hairy, with flat, yellow hairs to 4 mm long, the tip 0.9–1.1 mm wide, strongly recurved to coiled; style glabrous or sparsely glandular-pubescent proximally. CAPSULES 11–16 mm long, 5–8 mm wide, sparsely glandular-pubescent distally. SEEDS 1.2–1.5 mm long, dark, angled; Varieties 3 (2 in AZ).—Low deserts to subalpine, disturbed areas; 350–2800 m (1100–9200 ft); Apache, Cochise, Coconino, Gila, Greenlee, Maricopa, Mohave, Navajo, Pima, Pinal, Yavapai; range map: Fig. 17P; Apr–Oct; w US.

Penstemon ×mirus A. Nelson, a putative hybrid between *P. eatonii* and *P. palmeri*, has been reported from Arizona (A. Nelson 1938). See discussion following *P. bicolor*. We have two varieties, discerned as follows:

1. Peduncles, pedicels, and calyx lobes glandular-pubescent; anther cells 1.8–2.4 mm *Penstemon palmeri* var. *palmeri*
- 1' Peduncles, pedicels, and calyx lobes glabrous; anther cells 1.6–2(–2.2) mm *Penstemon palmeri* var. *eglandulosus*

Penstemon palmeri A. Gray var. *palmeri* — $2n = 16$.—Washes, roadsides, and canyon floors in creosote shrublands and pinyon-juniper woodlands up through subalpine forests; 350–2800 m (1100–9200 ft); Apache, Cochise, Coconino, Gila, Greenlee, Maricopa, Mohave, Navajo, Pima, Yavapai cos.; Mar–Aug; CA, CO, ID, NV, NM, UT, WA, WY.

Penstemon palmeri A. Gray var. *eglandulosus* (D. D. Keck) N. H. Holmgren — [*Penstemon palmeri* subsp. *eglandulosus* D. D. Keck].—Washes, roadsides, desert shrublands, pinyon-juniper woodlands 500–1900 m (1600–6300 ft); Cochise, Coconino, Mohave, Navajo cos.; Apr–Oct.; UT. *Penstemon palmeri* var. *eglandulosus* occurs at the s end of the UT Plateaus s to the AZ Strip and scattered locations further s.

Penstemon parryi (A. Gray) A. Gray (Charles Christopher Parry (1823-1890), prominent American botanist) Parry's beardtongue.—Perennial herbs; caudex woody. STEMS 1–20, 25–110 cm tall, ascending to erect, glabrous, glaucous. LEAVES thin, glabrous, glaucous, the margins entire; basal and proximal cauline leaves crowded, 30–125(–230) mm long, 4–25(–40) mm wide, the blades oblanceolate to spatulate, the bases tapered, petiolate, the apices rounded; cauline leaves 2–7 pairs, the blades lanceolate, 12–120 mm long, 1–25(–

35) mm wide, the bases clasping to auriculate-clasping, sessile, the apices obtuse to acute. THYRSES 5–50 cm long, interrupted, cylindric, the axes glabrous, the verticillasters (2–)4–14, the inflorescence branches 2 per node, 2–14-flowered; proximal bracts leaflike, lanceolate, 5–65 mm long, 1–11 mm wide, the margins entire, the apices acute; peduncles and pedicels spreading/ascending to erect, glabrous or pedicels sparsely glandular-pubescent, the peduncles to 35 mm long, the pedicels 2–17 mm long. FLOWERS: calyx lobes ovate to lanceolate, 2.4–3.8 mm long, 1–2 mm wide, glabrous or slightly glandular-pubescent, the margins entire or erose, narrowly scarious, the apices acute to rounded; corolla funnelform, bilaterally symmetric, bilabiate, 9–17 mm long from base to orifice, magenta to scarlet (sometimes turning blue on herbarium sheets, rarely cream), reddish purple-lined internally on both surfaces extending onto lobes of limb, externally and internally glandular-pubescent, internal lower surface white-lanate; tube 4–8 mm long; throat gradually expanded, the orifice 3–7 mm wide, the lobes projecting to spreading; stamens included, the anther cells fully dehiscent, explanate, 1–1.3 mm long, sutures smooth, the septa heights less than half the width of the cell walls; staminodes distal 1–6 mm densely hairy with flat, stiff, retrorse yellow hairs to 1.3 mm long, the tip 0.5–1.5 mm wide, straight. CAPSULES 4–9 mm long, 2–5 mm wide. SEEDS 0.7–1.6 mm long, brown to dark reddish brown. $2n = 16$. [*Penstemon puniceus* A. Gray var. *parryi* A. Gray; *P. shantzii* A. Nelson var. *incognatus* A. Nelson].—Rocky hillsides, washes, and canyons in desert and oak scrub, roadsides due to inclusion in seed mixes; Cochise, Coconino, Gila, Graham, Maricopa, Mohave, Pima, Pinal, Santa Cruz, Yavapai cos; 300–1900 m (1000–6300 ft); range map: Fig. 17O; (Feb–)Mar–May; Ariz.; Mex. (Son.)

Penstemon petiolatus Brandegee (with petioles) Petiolate beardtongue.—Perennial herbs or subshrubs. STEMS 5–30+, 5–25(–40) cm long, ascending to decumbent, glabrous or papillate scabrous to puberulent. LEAVES ovate, the margins: dentate to serrate-dentate; cauline leaves, 2–4(–7) pairs, distinctly petiolate, 12–35 mm long, 5–28 mm wide, the blades about as long as broad, the bases tapered to slightly cordate, the apices obtuse. THYRSES 1–4 cm long, crowded, the verticillasters 2–6, the inflorescence branches 2 per node, 1–3(–5)-flowered; proximal bracts leaf-like, ovate to lanceolate, 6–25 mm long, 2–14 mm wide, the margins entire or serrate-dentate, the apices acute; peduncles papillate scabrous; pedicels sparsely glandular-pubescent, the peduncles to 10 mm long, the pedicels 0.5–6 mm long. FLOWERS: calyx lobes lanceolate, 4–9 mm long, 1.2–2.5 mm wide, the margins entire, the apices acute, glandular puberulent externally; corolla weakly ventricose, 11–17 mm long from base to orifice, bright pink, violet-lined internally on the lower surface, externally sparsely glandular-pubescent, internal lower surface sparsely whitish or yellowish villous, internal upper surface and limb glandular-pubescent; tube 5–6 mm long; throat 4–6 mm wide, the lobes spreading; anther cells fully dehiscent, round when fully explanate, 0.7–1.1 mm long, the septa heights less than one half the width of the cell walls; staminodes yellow hairy for most of their length. CAPSULES 4–6 mm long, 4–5 mm wide. SEEDS 2–4 mm long, dark brown to blackish.—crevices in limestone outcrops and gravel washes in desert shrub communities and

juniper woodlands; Mohave Co.; 600–650 m (1900–2200 ft); range map; Fig. 18Q; May–Jun; NV, UT.

Penstemon pinifolius Greene (pine-like foliage) Pine-leaf beardtongue.—Subshrubs. STEMS 2–30+, many-branched from bases, erect, (5–)10–50 cm long, glabrous or retrorsely puberulent, the hairs pointed, usually in lines below leaf bases. LEAVES cauline, persistent, leathery, sparsely retrorsely puberulent, especially along the margins near bases, or glabrous, the hairs when present pointed, 10–40+ pairs (crowded proximally, widely spaced distally), 4–20(–32) mm long, 0.5–1.2 mm wide, the blades linear, the bases tapered to clasping, sessile, the margins entire, the apices mucronate. THYRSES (1–)3–10 cm long, interrupted, secund, the axes retrorsely puberulent to puberulent, or glabrous, the verticillasters 1–7, the inflorescence branches 1(–2) per node, 1–3-flowered; basal bracts leaflike, linear, 3–11 mm long, 0.3–0.7 mm wide, the margins entire, the apices acute; peduncles and pedicels ascending to erect, glandular-pubescent, the peduncles to 7(–10) mm long, the pedicels 2–8(–10) mm long. FLOWERS: calyx lobes lanceolate, 5–7 mm long, 1–2 mm wide, glandular-pubescent, the margins entire or erose, broadly scarious especially basally, the apices acuminate; corolla tubular, 14–25 mm long from base to orifice, scarlet (throat sometimes yellow- or orange-spotted, or entirely yellow), unlined internally, externally glandular-pubescent especially distally, internally hairy on the lower surface, the hairs extending onto limb, the hairs flat, long, white or yellow; tube 4–7 mm long; throat scarcely expanded, the orifice 2.3–5 mm wide, the lower lobes linear, projecting to reflexed, 6–8 mm long, the upper lobes projecting, fused most of their length; stamens exserted (often hidden by galeate upper lobes), the anthers spreading, the cells explanate, fully dehiscent, 0.9–1.2 mm long, the sutures smooth, the septa heights less than one half the width of the cell walls; staminodes included, distal 9–11 mm densely hairy with flat, yellow hairs to 1.4 mm long, the tip 0.1–0.2 mm wide, straight. CAPSULES 5–10 mm long, 3–4 mm wide. SEEDS 1.1–1.5 mm long, black, angled. $2n = 16$.—Rocky slopes, cliffs; Cochise, Greenlee cos.; 1650–3000 m (5400–9900 ft); range map; Fig. 18Q; Jun–Oct; NM.

Penstemon pseudoputus (Crosswh.) N. H. Holmgren (false putus, after *P. putus*) Kaibab beardtongue.—Perennial herbs; caudex woody. STEMS 1–10, 10–60 cm tall, 0–few branched from the base, decumbent to erect, the lower portions retrorsely puberulent. LEAVES dull green, the margins entire, retrorsely puberulent; basal and proximal cauline leaves crowded, sometimes absent at flowering, 15–110 mm long, 1–4(–6) mm wide, the blades linear to narrowly oblanceolate, the bases tapered, petiolate, the apices obtuse to acute; cauline leaves 6–11 pairs, 10–75 mm long, 0.5–3 mm wide, the blades linear, the bases tapered, sessile, the apices acuminate. THYRSES 4–25 cm long, interrupted, secund, the axes glabrous or puberulent, the verticillasters 3–11, the inflorescence branches 1–2 per node, 1–3-flowered; proximal bracts leaflike, 4–30 mm long, 0.5–2 mm wide, the margins entire, the apices acuminate; peduncles and pedicels ascending to erect, glabrous or puberulent, the peduncles

to 22 mm long, the pedicels 2–15 mm long. FLOWERS: calyx lobes ovate, or sometimes obovate or truncate, 2.5–4.5(–5) mm long, 1.5–2.4 mm wide, glabrous or sparsely puberulent, the margins erose or entire, scarious, the apices acute to acuminate or mucronate; corolla ventricose, bilabiate, (9–)12–18 mm long from base to orifice, blue to purple, rarely white, reddish purple-lined internally on the lower surface passing onto the limb; externally and internally glabrous, tube 5–7 mm long; throat gradually expanded, the orifice, (5–)7–10 mm wide, the lower lobes spreading, the upper lobes projecting or projecting-spreading; stamens: longer pair exserted, shorter pair exserted or not, the anthers spreading, the cells open-ended navicular, fully dehiscent, 1.2–1.5 mm long, the sides glabrous, the sutures papillate or denticulate, the teeth to 0.1 mm; staminodes exserted, glabrous, 0.5–0.8 mm wide, the tip straight to recurved. CAPSULES 7–14 mm long, 3–6 mm wide. SEEDS 1.5–2 mm long, dark brown, angled. [*Penstemon virgatus* A. Gray subsp. *pseudoputus* Crosswh., Amer. Midl. Naturalist 77: 35. 1967].—Pine to subalpine forests and meadows; Apache, Cochise, Coconino, Graham, Navajo, Yavapai cos., 1700–3650 m (5600–9100 ft); range map; Fig. 18Q; Jun–Sep; NM, UT. *Penstemon pseudoputus* primarily occurs on the Coconino and Kaibab plateaus of Coconino Co, with isolated occurrences in c and e AZ, sw UT, and w NM.

Intermediates between *P. putus* and *P. pseudoputus* with both stems and corolla throats hairy occur throughout the range of both species into w NM. These plants and others that could be placed within either species sometimes have broader leaf blades than is normally associated with either species, perhaps an influence from *P. virgatus*.

Penstemon pseudospectabilis M. E. Jones (false *spectabilis*, after *P. spectabilis*) Mojave beardtongue.—Perennial herbs, caudex woody. STEMS 1–25+, 25–100 cm tall, often many branched, ascending to erect, glaucous. LEAVES often thick, leathery or not, glaucous, the margins finely dentate to wavy or entire; basal and proximal cauline leaves crowded, 20–60(–165) mm long, 5–30(–50) mm wide, the blades ovate to lanceolate, the bases tapered, petiolate, the apices obtuse to acute; cauline leaves sessile, 4–7 pairs, 20–90 mm long, 15–70 mm wide, the blades ovate to triangular, the bases tapered to auriculate-clasping to connate-perfoliate on distal ones, the apices acute (blunt). THYRSES 5–55 cm long, interrupted or continuous, secund, the axes glabrous to sparsely glandular, the verticillasters 4–13, the inflorescence branches 2 per node, 1–3(–8)-flowered; proximal bracts leaflike, ovate to lanceolate, 10–50 mm long, 10–70 mm wide, connate-perfoliate, the margins entire to dentate, the apices acute to obtuse, glabrous; peduncles and pedicels ascending to erect, glabrous or glandular-pubescent, the peduncles to 21 mm long, the pedicels 2–17 mm long. FLOWERS: calyx lobes ovate, 3–4.5 mm long, 2–3 mm wide, glabrous or glandular-pubescent, the margins entire to erose, scarious to pink-margined, the apices acute to short-acuminate; corolla ventricose, strongly bilabiate, 13–27 mm long from base to orifice, rose-pink, reddish purple-lined internally on the lower surface, externally and internally glandular-pubescent, internally lacking flat hairs; tube 6–9 mm long, (2–3 times calyx lobes); throat gradually expanded, the orifice 5–9(–12) mm wide, the lower lobes spreading, the upper lobes projecting-spreading;

stamens: lower portion of the filament usually glabrous, longer pair reaching orifice or exserted, the anther cells fully dehiscent, explanate, 1–2 mm long, the sutures smooth, the septa heights less than one half the width of the cell walls; staminodes included to slightly exserted, glabrous or distal 1–2.5 mm hairy with yellow hairs to 1.5 mm long, the tip 0.2–0.4 mm wide, straight to recurved; style glabrous. CAPSULES 7–12 mm long, 4–6 mm wide, glabrous. SEEDS 1.1–2 mm long, dark brown to blackish, angled to somewhat rounded. $2n = 16$.—Washes, cliffs above watercourses, disturbed places; low desert to pine-oak woodlands; all but Santa Cruz Co.; 300–2300m (1000–7600 ft); range map; Fig. 18R; sw US, Mex.; Feb–Jun (Aug). Varieties 2, both in AZ.

See discussions following *P. bicolor* and *P. clutei*. *Penstemon* × *crideri* A. Nelson, a putative hybrid between *P. eatonii* and *P. pseudospectabilis*, has been reported from AZ (A. Nelson 1936).

1. Peduncles, pedicels, and calyx lobes glabrous, sometimes with sessile glands, but not glandular-pubescent..... *Penstemon pseudospectabilis* var. *connatifolius*
 1' Peduncles, pedicels, and calyx lobes glandular-pubescent..... *Penstemon pseudospectabilis* var. *pseudospectabilis*

Penstemon pseudospectabilis M. E. Jones var. *connatifolius* (A. Nelson) C. C. Freeman. (connate leaves).—[*Penstemon connatifolius* A. Nelson, Amer. J. Bot. 18: 437. 1931 (as *Pentstemon*); *P. pseudospectabilis* subsp. *connatifolius* (A. Nelson) D. D. Keck].—Apache, Cochise, Coconino, Gila, Graham, Greenlee, Maricopa, Mohave, Navajo, Pima, Pinal, Yavapai, Yuma cos; 350–2300 m (1200–7600 ft); Feb–Jun (Aug).

Penstemon pseudospectabilis M. E. Jones var. *pseudospectabilis*.—Maricopa, Mohave, Pima, Pinal, Yavapai, Yuma cos; 300–1550 m (1000–5100 ft), Mar–Apr; CA.

Glandular pubescence varies from scant to abundant, with plants from the lowest deserts (and a few outliers) having glandular-pubescence and those at higher elevations lacking glandular-pubescence.

Penstemon putus A. Nelson (pure) Black River beardtongue.—Perennial herbs; caudex woody. STEMS 1–10, 20–75 cm tall, 0-few branched from the base, decumbent to erect, glabrous. LEAVES bright green, the margins entire, the apices acute to acuminate; basal and proximal cauline leaves crowded, 15–125 mm long, 1–4(–6) mm wide, the blades linear to narrowly oblanceolate, glabrous, the bases tapered, petiolate; cauline leaves 5–7 pairs, 10–80 mm long, 0.5–3(–4) mm wide, linear, the bases truncate, sessile. THYRSES 5–40 cm long, interrupted, secund, the axes glabrous, the verticillasters 3–11, the inflorescence branches 1–2 per node, 1–2(–6)-flowered; proximal bracts leaflike, (2–)3–60 mm long, 0.5–2 mm wide, the margins entire, the apices acuminate; peduncles and pedicels erect, glabrous, the peduncles to 18 mm long, the pedicels 2–11 mm long. FLOWERS calyx lobes ovate, 1.6–4 mm long, 1.3–3.5 mm wide, glabrous, the margins erose or entire, scarious, the apices acuminate to caudate; corolla ventricose, bilabiate, 10–18(–20) mm long from base to orifice, white to pink, lavender, blue or violet, reddish purple-lined internally on the lower surface, externally glabrous, internally on the lower palate white-hairy; tube 4–6 mm long; throat gradually expanded, not

constricted at orifice, the orifice 7–10 mm wide, the lower lobes projecting-spreading to spreading, the upper lobes projecting; stamens: both pairs exerted, the anthers spreading, the cells open-ended navicular, fully dehiscent, 1.2–1.6 mm long, the sides glabrous, the sutures papillate or denticulate, the teeth to 0.1 mm; staminodes exerted, glabrous, the tip 0.4–1.4 mm wide, straight to recurved. CAPSULES 8–14 mm long, 4–9 mm wide, glabrous. SEEDS 2.2–3 mm long, yellow to dark brown, angled. $2n = 16$.—[*Penstemon virgatus* A. Gray subsp. *putus* (A. Nelson) Crosswhite].—pine forests; Apache, Coconino, Gila, Mohave, Navajo, Yavapai cos; 1750–2900 m (5700–9600 ft); range map: Fig. 18S; Jun-Sep; AZ endemic.

Penstemon putus occurs primarily along the Mogollon Rim in c and ec AZ and to the slopes of the San Francisco Peaks. Plants along the Mogollon Rim in e Coconino and w Navajo cos are often white-flowered. See notes with *P. pseudoputus* and *P. virgatus*.

Penstemon rostriflorus Kellogg (beaked flowers) Beak-flower beardtongue.—Perennial herbs, caudex and lower stems woody. STEMS 1–20+, 20–100 cm long, often many-branched. LEAVES: margins entire, petiolate, the apices acute to rounded; basal and proximal cauline leaves 8–52 mm long, 2–11 mm wide, the blades oblanceolate, the bases tapered; cauline leaves 4–16 pairs, 20–95 mm long, 2–18 mm wide. THYRSES 4–40 cm long, the verticillasters 3–12, the inflorescence branches (1–)2 per node, 1–5-flowered; proximal bracts lanceolate to linear, 6–46 mm long, 1–6 mm wide, the margins entire, the apices acute; peduncles and pedicels glandular-pubescent, the peduncles to 20 mm long, the pedicels 2–9 mm long. FLOWERS: calyx lobes ovate to lanceolate, 4–6 mm long, 1.5–2.4 mm wide, the margins entire, herbaceous or narrowly scarious, the apices acute to acuminate; corolla tubular, 11–22 mm long from base to orifice, orangish red to scarlet (throat usually yellowish or orangish), unlined internally, externally glandular-pubescent, internal lower surface sparsely white-puberulent; tube 3–5 mm long, the orifice 4–7 mm wide, the lower lobes spreading to reflexed, the upper lobes projecting; anthers horseshoe-shaped, the cells saccate, dehiscent at the connective and proximally up to 1/2 of length, distal portion indehiscent, 1.6–2.2 mm long, the sutures toothed, the teeth to 0.1 mm; staminodes glabrous, the tip, 0.2–0.4 mm wide. CAPSULES 5–11 mm long, 4–7 mm wide. SEEDS 1.4–1.9 mm long, light brown to brown. $2n = 16$. [*Penstemon bridgesii* A. Gray].—Rocky sagebrush shrublands, pinyon-juniper woodlands, montane forests; Apache, Cochise, Coconino, Gila, Graham, Greenlee, Maricopa, Mohave, Navajo, Yavapai cos; 850–2750 m (2800–9100 ft); range map: Fig. 18T; May–Oct; CA, CO, NV, NM, UT; Mex. (Baja C.)

Penstemon rydbergii A. Nelson (Per Axel Rydberg (1860-1931), prominent American botanist) Rydberg's beardtongue.—Perennial herbs; caudex woody. STEMS 1–several, 15–50 cm tall, from horizontal branching roots, decumbent, ascending, or erect, glabrous or puberulent, especially in lines below the leaf bases, not glaucous. LEAVES not thick, not leathery, not glaucous, the faces glabrous, the margins entire (lower margins sometimes ciliate); basal and proximal cauline leaves crowded, well-developed, 15–90 mm long, 5–18

mm wide, the blades spatulate to elliptic, the bases tapered, petiolate, the apices usually acute to rounded; cauline leaves 2–5 pairs, 10–100 mm long, 3–16 mm wide, the blades lanceolate to elliptic or oblong, the bases tapered to clasping, sessile or proximal ones short-petiolate, the apices acute. THYRSES 2–15 cm long, interrupted, cylindric, the axes retrorsely puberulent or woolly, at least in part, the verticillasters (1–)2–6, the inflorescence branches 2 per node, (3–)5–11-flowered, congested; proximal bracts leaflike, lanceolate, 10–30 mm long, 3–8 mm wide, the margins entire, the apices acute; peduncles and pedicels erect, glabrous to retrorsely puberulent, the peduncles to 13 mm long, the pedicels 0.5–4 mm long. FLOWERS: calyx lobes ovate to lanceolate, 4–6 mm long, 1–2.5 mm wide, glabrous or villous or very obscurely glandular, the margins erose to lacerate, narrowly to broadly scarious, the apices acute to long-acuminate or caudate; corolla ventricose, bilabiate, 7–11 mm long from base to orifice, blue or purple, externally glabrous to white lanate near the orifice, sometimes obscurely glandular, internally unlined, densely yellowish villous at the bases of the lower lobes, the tube 3–5 mm long, the throat gradually expanded, the orifice 2–4 mm wide, the lobes projecting-spreading; stamens: longer pair exserted, the anthers spreading, the cells navicular, fully dehiscent, 0.4–0.7 mm long, the sides glabrous, the sutures smooth or obscurely papillate; staminodes exserted, the distal 1.5–2 mm densely pilose with yellow hairs to 0.6 mm long, 0.2–0.4 mm wide, the tip 0.4 mm wide, straight to curled. CAPSULES 4–8 mm long, 2–4 mm wide, glabrous. SEEDS 0.5–1 mm long, silvery grey, angled to winged.—Subalpine meadows on the Kaibab Plateau and in the Chuska Mtns.; Apache, Coconino cos.; 2400–2800 m (7900–9200 ft); range map; Fig. 18S; Jun–Sep; CA, CO, ID, MO, NV, NM, OR, UT, WA, WY.

Arizona specimens match var. *aggregatus* with their entire-margined inflorescence bracts, but also match var. *rydbergii* with their long acuminate or long caudate calyx lobes and short anther cells. Freeman (2019) says that “Arizona plants are intermediate between var. *aggregatus* and var. *rydbergii*.” Most AZ specimens are now determined as *P. rydbergii* A. Nelson var. *aggregatus* (Pennell) N.H. Holmgren.

Penstemon spectabilis Thurber ex A. Gray (showy) Showy beardtongue.—Perennial herbs; caudex woody. STEMS 1–20+, (50–)80–120 cm, erect, glaucous or not. LEAVES basal and cauline, not leathery to leathery, the margins dentate to serrate, the teeth tips hardened; basal and proximal cauline leaves 40–100 mm long, 8–50 mm wide, blade oblanceolate to elliptic, the bases tapered, petiolate, the apex obtuse to acute; cauline leaves 5–9 pairs, 32–120 mm long, 10–45 mm wide, the blades ovate to lanceolate, the proximal usually auriculate-clasping, the distal usually cordate-clasping, the apex acute to acuminate. THYRSES 15–40 cm, interrupted, cylindric, axis glabrous or glandular-pubescent distally, the verticillasters 8–28, the inflorescence branches 2 per node, 2–10-flowered, the proximal bracts leaflike, ovate to lanceolate, 15–45 mm long, 10–35 mm wide, the margins coarsely toothed to entire, the apices acuminate; peduncles and pedicels spreading to ascending, glabrous or glandular-pubescent, peduncles 5–25 mm, pedicels 3–20 mm. FLOWERS: calyx lobes round to ovate or lanceolate, 3–5.5 mm long, 2.5–3.2 mm wide, glabrous or glandular-pubescent, the margins

entire or erose to denticulate, broadly scarious, the apex acute, sometimes slightly caudate; corolla ventricose-ampliate, strongly bilabiate, 18–24 mm long from base to orifice, lavender, blue, pink, or purple, reddish purple-lined internally on both surfaces extending onto the lobes of limb, externally glandular-pubescent, internal abaxial surface glabrous or sparsely white-lanate, adaxial surface glandular-pubescent; tube 6–10 mm long; throat abruptly expanded, not or slightly constricted at orifice, the orifice 7–14 mm wide, the upper lobes projecting, the lower lobes projecting to reflexed; stamens included or longer pair reaching orifice, the filaments of shorter pair glandular-puberulent at bases, the anther cells navicular (intermediate between navicular and open-ended navicular), fully dehiscent, 1.8–2.4 mm, glabrous to papillate, the sutures papillate or denticulate, the teeth to 0.1 mm; staminodes proximal 1–2 mm glandular-pubescent, distally glabrous or less commonly the distal 1 mm sparsely pilose with yellow hairs to 0.5 mm long, the tip 0.5–1.2 mm wide, straight. CAPSULES 5–14 mm long, 3–8 mm wide glabrous. SEEDS 1.5–2.5 mm dark brown, angled. $2n = 16$. Vars. 3, var. *spectabilis* with glabrous pedicels and calyx lobes in AZ.—Roadside gravels, one collection in Coconino Co., 20 mi. s of Flagstaff along Hwy. 89 (*Neese 10667*, NY00661139); no range map; Apr-Jul; CA, NV, Mex. (Baja C.).

This species has probably not persisted in AZ.

Penstemon stenophyllus A. Gray (narrow-leaved) Sonoran beardtongue.—Perennial herbs; caudex woody. STEMS 1–3, 15–90 cm tall, retrorsely puberulent, sometimes glabrescent. LEAVES glabrous or retrorsely puberulent, not glaucous, linear, the bases tapered, the margins entire, the apex acute; basal leaves usually absent at anthesis; basal and proximal cauline leaves petiolate, 16–95 mm long, 2–6 mm wide, the apices acute; cauline leaves 6–30 pairs, 30–110 mm long, 1–6 mm wide, sessile. THYRSES 5–40 mm long, cylindric to somewhat secund, the axes glabrous, the verticillasters (2–)3–6(–8), the inflorescence branches (1–)2 per node, (1–)2–4(–5)-flowered; proximal bracts leaflike, linear, 5–55(–80) mm long, 0.5–6 mm wide, the margins entire, the apices acute; peduncles and pedicels ascending to erect, glabrous to glandular-pubescent, the peduncles to 75 mm long, the pedicels 5–25 mm long. FLOWERS: calyx lobes ovate to elliptic, 3.5–9 mm long, 1.6–3(–3.5) mm wide, glabrous or glandular-pubescent, the margins erose, broadly scarious, the apices acute to caudate; corolla ventricose, 17–35 mm long from base to orifice, violet to blue, lavender, or purple, reddish purple-lined internally on the lower surface, externally glandular-pubescent, internally glabrous; tube 7–10 mm long; throat abruptly expanded, the orifice 7–14 mm wide, the lower lobes projecting-spreading, the upper lobes spreading; stamens included, the anthers horseshoe-shaped to divergent, the cells navicular-bulging, often misshapen, fully dehiscent or not, sometimes proximally indehiscent, 1.4–2.3 mm long, the sides glabrous, the sutures denticulate, the teeth to 0.15 mm; staminodes exserted, glabrous, the tip 1–2.1 mm wide, curled. CAPSULES 7–11 mm long, 4–8 mm wide. SEEDS 2–3 mm long, brown to dark brown.—desert grasslands, openings in pine and pine-oak woodlands; Huachuca and

Patagonia Mtns.; Cochise, Pima, Santa Cruz cos.; 1300–2200 m (4470–7200 ft); range map; Fig. 18S; Jul–Oct.; Mex.

Penstemon strictiformis Rydb. (with the form of *strictus*) Stiff beardtongue.—Perennial herbs; caudex woody. STEMS 1–5, 10–65 cm tall, ascending to erect, glabrous, not glaucous. LEAVES glabrous, not glaucous, rarely puberulent, the margins entire to antrorsely-scabrous, the apex acute to rounded; basal and proximal cauline leaves crowded, 15–85 mm long, 2–12 mm wide, the blades oblanceolate, antrorsely scabrous, the bases tapered, petiolate; cauline leaves 4–6 pairs, 3–80 mm long, 2–18 mm wide, the blades lanceolate to oblanceolate, the bases tapered to truncate or clasping, sessile. THYRSES 5–35 cm long, continuous to interrupted, somewhat secund, the axes glabrous or obscurely glandular, the verticillasters 2–10, the inflorescence branches (1–)2 per node, 2–5-flowered; proximal bracts leaflike, lanceolate, 10–42 mm long, 3–12 mm wide, the margins entire, the apices acute; peduncles and pedicels ascending to erect, glabrous or obscurely glandular, peduncles to 13 mm long, pedicels 2–15 mm long. FLOWERS: calyx lobes ovate to lanceolate, 5–7.5 mm long, 1.5–3 mm wide, glabrous or basal portion obscurely glandular, the margins erose, broadly scarious, the apices acuminate to caudate; corolla ventricose, bilabiate, 12–23 mm long from base to orifice, lavender to blue, unlined internally, externally and internally glabrous; tube 5–7 mm long; throat gradually to abruptly expanded, the orifice, not to slightly constricted, 6–9 mm wide, the lower lobes projecting-spreading, the upper lobes projecting to projecting-spreading; stamens: longer pair exserted, the anthers divergent, the cells scoop-shaped, sigmoid, the connective and proximal 1/4–1/3 indehiscent, dehiscent distally, 1.8–2.4 mm long, the sides lanate/villous, the hairs white, to 1 mm, the sutures denticulate, the teeth to 0.1 mm; staminodes included, distal 2–7 mm sparsely to moderately villous with yellow or white hairs to 1.2 mm long, the tip 0.5–0.8 mm wide, straight to recurved. CAPSULES 7–11 mm long, 4–6 mm wide. SEEDS 1.5–2 mm long, brown, angled. [*Penstemon strictus* Benth. subsp. *strictiformis* (Rydb.) D. D. Keck].—Pine and juniper woodlands; Apache, Coconino cos; 1800–2400 m (6100–7800 ft); range map: Fig. 19U; May–Aug; CO, NM, UT.

Penstemon strictiformis may hybridize with *P. strictus* and *P. virgatus*, and perhaps other species. See notes under *P. strictus*.

Penstemon strictus Benth. (tightly bunched stems, straight and rigid) Rocky Mountain beardtongue.—Perennial herbs; caudex woody. STEMS 1–7, 30–75 cm tall, from an underground branching caudex, ascending to erect, glabrous or basal portion slightly papillate hairy, rarely distinctly puberulent, not glaucous. LEAVES glabrous or obscurely puberulent proximally, rarely distinctly puberulent, not glaucous, the bases tapered, the margins entire to antrorsely-scabrous, petioles sometimes slightly ciliate; basal and proximal cauline leaves crowded, 20–110(–150) mm long, 2–13(–20) mm wide, the blades oblanceolate, petiolate, the apices rounded; cauline leaves 4–10 pairs, 10–100 mm long, 2–10(–24) mm wide, the blades oblanceolate to elliptic, sessile to petiolate, the apices acute. THYRSES 6–16(–40) cm long,

interrupted to continuous, secund, the axes glabrous, the verticillasters 6–12(–20), congested, overlapping by about 1/3 their length, the inflorescence branches 2 per node, 1–2(–5)-flowered; proximal bracts leaflike, elliptic to lanceolate (ovate), 10–90 mm long, 1–8(–22) mm wide, the margins entire, the apices acuminate; peduncles and pedicels ascending to erect, glabrous, the peduncles 3–12 mm long, the pedicels 1–12 mm long. FLOWERS: calyx lobes ovate, 2.5–4(–5) mm long, 1.3–2.4(–3) mm wide, glabrous, the margins erose, broadly scarious, the apices rounded to acute; corolla ventricose-ampliate, bilabiate, 13–20 mm long from base to orifice, violet to pale or deep blue, violet-lined internally on the lower surface, externally glabrous, internally nearly glabrous to puberulent; tube 5–8 mm long; throat expanded, the orifice 6–12 mm wide, the lower lobes spreading or projecting, the upper lobes projecting; stamens: longer pair exserted, the anthers divergent to spreading, the cells scoop-shaped, connective and proximal up to 1/5 indehiscent, 1.2–1.7 mm long, the sides sparsely lanate/villous, the hairs white, to 2 mm long, the sutures denticulate, the teeth to 0.1 mm; staminodes included, glabrous or distal 1–5 mm sparsely villous with clear to yellow hairs to 1 mm long, the tip 0.5–0.6 mm wide, straight to curved. CAPSULES 7–12(–15) mm long, 4–6(–7) mm wide. SEEDS 1.5–2.4 mm long, brown, angled. $2n = 16$. [*Penstemon strictus* Bentham subsp. *angustus* Pennell].—gravelly sagebrush shrublands, pinyon or oak woodlands, spruce-aspen forests; Native to Apache Co, perhaps Navajo Co, introduced into Coconino, Greenlee, Mohave, Pima, Yavapai cos.; 1700–2850 m (5500–9400 ft); range map: Fig. 19V; May–Sep; CA, CO, NM, UT, WY.

In AZ, plants we have called *Penstemon strictus* take two forms. One form matches plants more widely known throughout the West and have been used in seed mixes introduced along roadsides, probably as the horticultural product ‘Bandera’ (Lindgren 2006, USDA 1982) derived from native plants near Mountainaire, NM. Our native plants from n Apache Co. do not match *P. strictus* from other parts of the West. The introduced plants are more robust, with broader, greener leaves, more flowers that are a deeper blue, and have larger capsules than the native plants. The parenthetical () measurements in this description are from specimens of introduced plants. Our ‘native’ *P. strictus* is the same form that is seen into UT at least as far n as the Abajo Mtns. I suspect our native *P. strictus* is a stable hybrid formed by introgression between *P. comarrhenus* and/or *P. strictiformis*. It is possible that our native plants should be recognized at the specific level, separate from *P. strictus*. *Penstemon strictus* apparently hybridizes with *P. barbatus*, *P. strictiformis*, *P. comarrhenus*, and perhaps *P. pseudoputus* and *P. virgatus*; perhaps others. See notes following *P. comarrhenus*.

Penstemon subglaber Rydb. (almost glabrous) Northern smooth beardtongue.—Perennial herbs; caudex woody. STEMS 1–4, (10–)18–90(–130) cm, erect, usually glabrous proximally, usually sparsely glandular distally. LEAVES basal and cauline, glabrous, entire; basal and proximal cauline leaves 35–140 mm long, 8–24 mm wide, blade usually oblanceolate to lanceolate, base tapered, petiolate, margins entire, apices obtuse to acute; cauline leaves 3–6 pairs, 28–95 mm long, 4–16 mm wide, blade lanceolate to oblanceolate, base tapered to

clasping, sessile to slightly petiolate, apices acute. THYRSE (4–)12–38 cm long, interrupted, secund, axes glabrous or glandular-pubescent, verticillasters 4–12, the inflorescence branches 2 per node, 1–6-flowered; proximal bracts leaf like, lanceolate, 5–75 mm long, 1–15(–22) mm wide, margins entire, apex acuminate; peduncles and pedicels ascending to erect, glandular-pubescent, sometimes sparsely so, peduncles to 30 mm, pedicels 1–11 mm. FLOWERS: calyx lobes: ovate to lanceolate, 4–8 mm long, 1.5–2.8 mm wide, glandular-pubescent; corolla ventricose, 17–20 mm from base to orifice, blue to purple, externally glandular-pubescent, internally glabrous, tube 6–10(–11) mm, throat gradually expanded, not constricted at orifice, the orifice 7–10 mm wide, the lower lobes spreading, the upper lobes projecting; stamens included or longer pair reaching orifice, anther cells scoop-shaped, proximally indehiscent, though the indehiscent portion can be so short as to appear fully dehiscent, 1.5–2.1 mm, sides sparsely hairy, the hairs white, to 0.4 mm, especially distal to the sutures, the sutures denticulate, the teeth to 0.1 mm; staminodes with distal 2–3 mm sparsely villous with yellow hairs to 0.7 mm. CAPSULES 10–15 mm long, 5–8 mm wide. SEEDS 1.8–2.5 mm long, brown, angled.—subalpine forests and meadows; introduced to Coconino Co.; 2600–2700 m (8500–8900 ft); range map: Fig. 19U; Jun–Sep; ID, UT, WY.

Penstemon subglaber is native to the central Rockies and Utah plateaus; probably introduced to the Kaibab Plateau in AZ, where it could be confused with (the also introduced) *P. strictus* ‘Bandera’. The glandular corollas and short anther cell hairs of *P. subglaber* will separate them.

Penstemon subulatus M. E. Jones (calyx lobes subulate tipped) Hackberry beardtongue.—perennial herb; caudex woody. STEMS 1–8, 20–75 cm tall, ascending to erect, usually glaucous. LEAVES basal and cauline, leathery, glabrous, glaucous, the margins entire; basal and proximal cauline leaves crowded, 10–90 mm long, 1–17 mm wide, the blades oblanceolate, the bases tapered, petiolate, slightly papillate/scabrous, the apices rounded to acute; cauline leaves 5–9 pairs, 15–65(–120) mm long, 1–10(–15) mm wide, reduced upwards, the blades lanceolate to linear or linear-subulate, the bases clasping to auriculate-clasping, sessile, the apices acute to rounded. THYRSES 5–40 cm long, interrupted, cylindric, the axes glabrous, the verticillasters 4–14, the inflorescence branches (1–)2 per node, 1–5-flowered, sometimes with several branches; proximal bracts leaflike, lanceolate to linear, 6–30 mm long, 1–6 mm wide, the margins entire, the apices acute; peduncles and pedicels erect, glandular or glabrous, the peduncles to 27 mm long, the pedicels 1–20 mm long. FLOWERS: calyx lobes ovate to lanceolate, 2–4.6 mm long, 1.4–2.1 mm wide, glabrous or with glands along the margins, the margins entire or erose, broadly scarious, the apices acute to caudate or subulate; corolla tubular, nearly radially symmetric, weakly bilabiate, 13–25 mm long from base to orifice, scarlet, unlined or lined into the lobes, internally and externally glabrous; throat scarcely expanded, the orifice 2–5 mm wide, the lobes projecting-spreading, the limb 2–7 mm wide; stamens: longer pair reaching orifice or exserted, the anther cells fully dehiscent, explanate, 0.75–1.1(–1.7) mm long, often shorter than wide, sutures smooth, the septa heights

less than one half the width of the cell walls; staminodes glabrous, the tip 0.2–0.5 mm wide, terete or flattened, straight. CAPSULES 6–12 mm long, 3–7 mm wide. SEEDS 1.2–2.5 mm long, brown. $2n = 16$. Rocky slopes, mesas, canyons; widespread below the Mogollon Rim; Gila, Graham, La Paz, Maricopa, Mohave, Pima, Pinal, Santa Cruz, Yavapai, Yuma cos; 400–2000 m (1300–6600 ft); range map: Fig. 19U; (Feb–)Mar–May; AZ endemic; but to be expected in Mexico.

Penstemon subulatus can have pollen grains adhering to the surfaces of the corolla which can appear similar to the glandular pubescence of *P. utahensis* corollas. Look carefully for stalked glands both inside and outside the corolla to discern these.

Penstemon superb A. Nelson (superb) Superb beardtongue.—Perennial herbs; caudex woody. STEMS 1–15, 30–150 cm tall, ascending to erect, glaucous. LEAVES thick, glabrous, glaucous, the margins entire; basal and proximal cauline leaves crowded, 30–160 mm long, 5–40 mm wide, the blades spatulate to oblanceolate or elliptic, the bases tapered, petiolate, the apices rounded to acute; cauline leaves 3–6 pairs, 20–110 mm long, 4–45 mm wide, the blades ovate to oblanceolate, the bases tapered to cordate-clasping to connate-perfoliate, sessile, the apices rounded to acute. THYRSES 25–60 cm long, interrupted, cylindric, the axes glabrous, the verticillasters 9–15, the inflorescence branches 2 per node, (1–)3–9-flowered; proximal bracts leaflike, lanceolate, 10–40 mm long, 3–25 mm wide, the margins entire, the apices acute; peduncles ascending to erect, glabrous [pedicels sparsely glandular-pubescent], the peduncles 1–10(–20) mm long, the pedicels 1–14 mm long. FLOWERS: calyx lobes ovate to lanceolate, 2–4.5 mm long, 1.2–2.1 mm wide, sparsely glandular-pubescent proximally and along the margins, sometimes glabrous, the margins entire or erose, narrowly scarious, the apices acute to acuminate; corolla tubular-funnelform, nearly radially symmetric, weakly bilabiate, 12–23 mm long, orangish pink to red, lined internally, externally and the internal lower surface glandular-pubescent; tube 5–7 mm long; throat scarcely expanded, the orifice 4–6 mm wide, the lobes spreading; stamens included, the anther cells fully dehiscent, explanate, 1–1.5 mm long, the sutures smooth, septa heights less than one half the width of the cell walls; staminodes with distal 2–3 mm densely hairy with retrorse hairs to 0.7 mm long, the tip 0.5–1 mm wide, straight. CAPSULES 10–15 mm long, 4–7 mm wide. SEEDS 1.4–2 mm long, dark brown to blackish. $2n = 16$. [*Penstemon puniceus* A. Gray].—gravelly to rocky canyons, slopes, washes in desert grasslands, and pinyon-juniper and oak woodlands; Cochise, Gila, Graham, Greenlee, Pima, Pinal cos; 800–2000 m (2600–6700 ft); range map: Fig. 19V; (Mar–)Apr–Jun. NM; Mex. (Chi., Son.).

Penstemon superb resembles *P. parryi*, but has broader leaves, corollas that are orangish pink to red, more regular, and without white-pilose hairs on the lower surface in the throats. Both species have staminodes with broad, flat, retrorse hairs.

Penstemon thompsoniae (A. Gray) Rydb. (Ellen Powell Thompson (1840–1911), early western botanist) Thompson's beardtongue.—Cespitose perennial herbs. STEMS 1–30+, 2–15 cm long, from an underground branching caudex, prostrate or ascending, retrorsely hairy, the

hairs scalelike, appressed, white, round-tipped. LEAVES cauline only, 2–10(–20) pairs, 6–24 mm long, 1.5–7 mm wide, the blades obovate to spatulate, the bases tapered, petiolate, the margins entire, the tips mucronate, densely retrorsely puberulent, about equally hairy on both surfaces, the hairs scalelike, strongly flattened, appressed, white, round-tipped, usually up to 2–3 times longer than wide. THYRSES 1–6 cm long, continuous, secund, the axes retrorsely hairy, the hairs scalelike, appressed, white, sometimes glandular-pubescent distally, the verticillasters (1–)3–7, the inflorescence branches 1(–2) per node, 1–3(–5)-flowered; proximal bracts leaflike, spatulate to oblanceolate, 5–19 mm long, 1.5–4 mm wide, the margins entire, the apices mucronate; peduncles and pedicels spreading to ascending, retrorsely puberulent with sharp-tipped hairs and sometimes sparsely glandular-pubescent, the peduncles to 3 mm long, the pedicels 1–3 mm long. FLOWERS: calyx lobes lanceolate, 4–8 mm long, 1.2–1.7 mm wide, (calyx tube about 1 mm long), sparsely glandular-pubescent and retrorsely puberulent, the hairs appressed, white, scalelike, the margins entire, herbaceous or narrowly scarious, when hyaline margins present, they extend halfway (rarely 2/3) from base to tip, the apices acuminate or with long caudate tips; corolla ampliate, (7–)10–18 mm long from base to orifice, blue to purple, reddish violet-lined internally on the lower surface, externally glandular puberulent, internal lower surface yellow-lanate; tube 4–8 mm long; throat gradually inflated, the orifice 3–6 mm wide, constricted or not, the lobes projecting or spreading; stamens reaching orifice or longer pair exserted, the filaments glabrous, the anthers divergent, the cells navicular, fully dehiscent, 0.9–1 mm long, the sides sometimes papillate, the sutures toothed; staminodes exserted, distal 5–8 mm densely hairy with yellow hairs to 0.8(–1) mm long, the tip flattened, 0.3–0.4 mm wide, recurved. CAPSULES 3.5–8 mm long, 3–5 mm wide. SEEDS 1.2–2.1 mm long, dark brown to blackish, rounded to slightly angled. [*Penstemon pumilus* Nutt. var. *thompsoniae* A. Gray, *P. thompsoniae* var. *desperatus* Neese; *P. thompsoniae* subsp. *jaegeri* D. D. Keck].—sandy to gravelly soils in sagebrush shrublands and pine woodlands; Apache, Coconino, Graham, Mohave, Navajo, Yavapai cos.; 550–2200 m (1800–7000 ft); range map: Fig. 15E; Apr–Aug(–Oct). CA, NV, UT.

See notes with *P. caespitosus*.

Penstemon thurberi Torr. (George Thurber (1821–1890), prominent American botanist) Thurber's beardtongue.—Herbaceous to shrubby. STEMS 1–30+, 20–60 cm long, many-branched throughout, glabrous. LEAVES cauline only, 8–28 pairs, 5–32 mm long, 0.3–1.5 mm wide, sessile, the margins scabrous or glabrous, the apices mucronate. THYRSES 1–32 cm long, the verticillasters 3–21, the inflorescence branches (1–)2 per node, 1(–2)-flowered; proximal bracts leaf-like, linear, 2–18 mm long, 0.2–1 mm wide, scabrous to glabrous, the margins entire, the apices mucronate; peduncles and pedicels glabrous, the peduncles to 12 mm long, the pedicels 1–4 mm long. FLOWERS: calyx lobes ovate, (1.4–)2–3(–4) mm long, 0.8–2 mm wide, the margins entire or erose, broadly scarious, the apices acute; corolla ampliate-funnelform, 8–12 mm long from base to orifice, white to blue-ish, externally glabrous, lower side of the orifice pubescent, the hairs 0.5 mm long, the orifice 2–5 mm wide,

the lobes spreading, the limb 5–13 mm wide; stamens, longer pair exerted, shorter pair included, the anther cells explanate, rarely open-ended navicular, fully dehiscent, 0.6–0.8 mm long, the septa heights less than one half the width of the cell walls; staminodes included, glabrous. CAPSULES 5–8 mm long, 3–5 mm wide, glabrous. SEEDS 1.5–2.8 mm long, dark or reddish brown. [*Penstemon thurberi* var. *anestius* Reveal & Beatley, *Penstemon scoparius* A. Nelson].—sandy or rocky slopes in creosote shrublands, chaparral, and pinyon-juniper woodlands; s and w of the Mogollon Rim; Cochise, Gila, Graham, Maricopa, Mohave, Pima, Pinal, Yavapai cos.; 700–2450 m (2400–8000 ft); range map; Fig. 19W; Mar–Oct.; CA, NV, NM, TX; Mex. (BC, Chi).

See notes with *P. ambiguus*.

Penstemon trichander (A. Gray) Rydb. (hairs on the anther cells) Beard-lip beardtongue.—Perennial herbs; caudex woody. STEMS 1(–3), 20–100 cm tall, mostly erect, sometimes ascending, proximally obscurely puberulent, distally glabrous. LEAVES usually short-hairy, the bases tapered, the margins entire, the apices rounded to acute; basal and proximal cauline leaves crowded, 20–100 mm long, 3–25 mm wide, the blades oblanceolate, petiolate; cauline leaves 3–6 pairs, 10–110 mm long, 1–11 mm wide, the blades oblanceolate to linear, cuneate or blunt, not cordate-based, sessile. THYRSES 7–40 cm long, the axes glabrous, the verticillasters 4–12, the inflorescence branches (1–)2 per node, (1–)2–5-flowered; proximal bracts leaflike, linear, 10–70 mm long, 1–3 mm wide, the margins entire, the apices acute; peduncles and pedicels spreading to ascending, glabrous, the peduncles to 35 mm, the pedicels 2–37 mm. FLOWERS: calyx lobes ovate to lanceolate, 2.2–6(–9) mm long, 1.5–3.2 mm wide, glabrous or slightly glandular, the margins entire or erose, broadly scarious, the apices acute; corolla tubular-funnelform, 20–38 mm long, red, dark red-lined internally on the lower surface, externally glabrous or slightly glandular, internally glabrous; tube 5–8 mm long, the orifice 4–8 mm wide, the lower lobes strongly reflexed or less-commonly projecting, the upper lobes projecting, (5–)7–10 mm long; stamens exerted, the anthers spreading, the cells scoop-shaped, distally dehiscent, connective and proximally 1/4–1/3 indehiscent, 1.7–2.2 mm long, the sides sparsely lanate-villous, the hairs white, to 1.5 mm, the sutures papillate or denticulate, the teeth to 0.06 mm or smooth; staminode included or exerted, glabrous, the tip 0.6–0.8 mm wide, straight or slightly recurved. CAPSULES 9–15 mm long, 4–8 mm wide. SEEDS 2–3 mm long, brown. $2n = 16$ [*Penstemon barbatus* subsp. *trichander* (A. Gray) D. D. Keck].—pinyon-juniper woodland to subalpine forest; native in Apache, Navajo cos., introduced to Mohave Co. (J. Springer email Feb 23, 2018); 1700–2900 m (5700–9600 ft); range map; Fig. 14C; Jun–Sep; CO, NM, UT.

Penstemon trichander occurs in the Four Corners region. Crosswhite (1965) noted that *P. b.* var. *trichander* occurs where var. *torreyi* and *P. strictus* are sympatric and hypothesized that it is the product of hybridization and introgression between *P. barbatus* and *P. strictus*. An alternate theory supported by the pubescence of the stems and leaves of *P. trichander* is that *P. trichander* resulted from hybridization between *P. barbatus* and *P. comarrhenus*.

Though *P. trichander* may have originated from hybridization, that it is nearly allopatric with *P. barbatus* and that it does not have the wide variation typical of a hybrid swarm indicates that it is breeding true and should be considered at the species level. We do see specimens that may be hybrids or backcrosses between *P. trichander* and *P. comarrhenus*, with deep purple corollas and lanate anther cells. Herbarium specimens remain determined as *P. barbatus* var. *trichander*. Also, see notes with *P. barbatus*.

Penstemon utahensis Eastw. (Utah) Utah beardtongue.—Perennial herbs; caudex woody. STEMS 1–5(–20+), 15–75 cm tall, ascending to erect, glaucous. LEAVES leathery, glaucous; basal and proximal cauline leaves crowded, 15–115 mm long, 1–15 mm wide, the blades oblanceolate, the bases tapered, petiolate, the margins entire or papillate/scabrous, the apices obtuse to acute, sometimes mucronate; cauline leaves (1–)2–4(–5) pairs, 10–75 mm long, 1–17 mm wide, the blades elliptic to lanceolate or, rarely, ovate, auriculate, the apices rounded to acute, sometimes mucronate. THYRSES 5–45 cm long, interrupted, somewhat secund, the axes glabrous, the verticillasters 5–15, the inflorescence branches 2 per node, 1–4-flowered; proximal bracts leaflike, lanceolate, 5–55 mm long, 1–18 mm wide, the margins entire, the apices acute to acuminate, sometimes mucronate; peduncles and pedicels erect, glabrous, the peduncles to 13 mm long, the pedicels 1–15 mm long. FLOWERS: calyx lobes ovate, 2–5.5 mm long, 1.3–4 mm wide, glandular especially at the apices or glabrous, the margins erose, broadly scarious, the apices acute, sometimes caudate; corolla tubular-salverform, bilaterally symmetric, bilabiate, 10–22 mm long from base to orifice, red to crimson, red or white, unlined or lined internally on both surfaces, rarely extending onto the limb, externally glandular-pubescent especially distally, internal surfaces glandular-pubescent; throat scarcely inflated, the orifice 3–8 mm wide, constricted or not, all lobes spreading or the lower lobes projecting-spreading, the limb (3–)7–17 mm wide; stamens included, or longer pair reaching orifice, the anthers reflexed, the cells explanate, fully dehiscent, rarely open-ended navicular, 0.6–1.2 mm long, the sutures smooth, the septa heights less than one half the width of the cell walls; staminodes glabrous, flattened distally, the tip 0.3–0.6 mm wide, straight. CAPSULES 5–10 mm long, 5–8 mm wide. SEEDS 1.7–3.8 mm long, brown.—sagebrush shrublands, pinyon-juniper woodlands; Coconino, Mohave, Navajo cos; 1000–2000 m (3600–6600 ft); range map: Fig. 19W; Apr–Jun.; CA, CO, NV, UT.

In Mojave Co., populations of *P. utahensis* can have corollas with or without nectar guides on the same plant.

Penstemon virgatus A. Gray (wand-like inflorescence) Upright blue beardtongue.—Perennial herbs; caudex woody, not cespitose. STEMS 1–3(–7+), 20–85 cm tall, erect, puberulent or less commonly glabrous, dull green. LEAVES gray green, puberulent or less commonly glabrous, the margins entire, the apex obtuse to acute; basal and proximal cauline leaves crowded, often deciduous at flowering, 20–110 mm long, 2–15(–20) mm wide, oblanceolate, elliptic or spatulate, the bases tapered, petiolate; cauline leaves: 3–11 pairs,

sessile, 20–100 mm long, 2–12 mm wide, the blades lanceolate, widths reduced from the basal leaves, the bases tapered to truncate. THYRSES 5–55 cm long, crowded and continuous to lax and interrupted, secund, the axes puberulent or glabrous, the verticillasters 3–14, the inflorescence branches (1–)2 per node, 1–6-flowered; proximal bracts leaflike, lanceolate, 7–50 mm long, 2–7 mm wide, the margins entire, apices obtuse to acute; peduncles and pedicels ascending to erect, puberulent or glabrous, the peduncles to 8(–20) mm long, the pedicels 1–15 mm long. FLOWERS: calyx lobes ovate to elliptic, 2.2–4.5 mm long, 1.3–3 mm wide, glabrous or puberulent, the margins erose to entire, sometimes slightly glandular, scarious, the apices acute to cuspidate; corolla ventricose, bilabiate, 12–18 mm long from base to orifice, violet to lavender, pink-lavender, or purple, reddish purple-lined internally on the lower surface passing onto limb, externally glabrous, internal lower surface sparsely white-villous; tube 5–8 mm long; throat gradually to abruptly inflated, slightly constricted at orifice, the orifice 6–12 mm wide, the lower lobes spreading to reflexed, the upper lobes projecting to arched-projecting; stamens: longer pair exserted, shorter pair often exserted; anthers spreading, the cells open-ended navicular, fully dehiscent (sometimes shortly indehiscent proximally), 1.5–1.8 mm long, the sides glabrous, the sutures denticulate, the teeth to 0.1 mm, the septa heights nearly the width of the cell walls; staminodes reaching orifice or exserted, glabrous, the tip 0.7–1.2 mm wide, straight or recurved. CAPSULES 8–14 mm long, 4–8 mm wide, glabrous. SEEDS 1.4–2.4 mm long, dark brown, angled. $2n = 16$.—pine forests; Apache, Cochise, Coconino, Gila, Mohave, Navajo, Yavapai cos.; 1500–2950 m (4900–9600 ft); Jun–Sept; range map: Fig. 19X; CO, NM.

Penstemon virgatus is sporadic throughout much of AZ but most prevalent in s Coconino Co. Freeman (2019) treats two varieties of *P. virgatus* based on stem and leaf pubescence, not recognizing the glabrous variety *asa-grayi* in AZ. However, our plants vary in pubescence from glabrous to hairy, a character which in this case, seems taxonomically insignificant. Because *P. virgatus* previously encompassed *P. deaveri*, *P. pseudoputus*, and *P. putus*, persistent misidentifications continue to cloud our understanding of the species. *Pentemon virgatus* sometimes blends with *P. nudiflorus*, *P. pseudoputus* and *P. putus*. Our glabrous plants may be introgressants with *P. nudiflorus*. See notes at the end of the *P. strictus* description.

Penstemon watsonii A. Gray (for Sereno Watson (1826–1886), American botanist) Watson’s beardtongue.—Perennial herbs, caudex woody. STEMS 1–15+, 15–60 cm tall, ascending to erect, glabrous or puberulent. LEAVES basal absent or poorly developed, not thick, not leathery not glaucous, glabrous or puberulent, not glandular pubescent distally; cauline 4–8 pairs, 20–70(–80) mm long, (1–)5–25(–35) mm wide, blade lanceolate to elliptic, base tapered or clasping, short-petiolate to sessile, margins entire, apex acute. THYRSES continuous or interrupted, cylindric, (1–)5–18 cm, axis puberulent or not, verticillasters 2–7(–10), the inflorescence branches 2 per node, (2–)6–14 flowered; proximal bracts leaflike, lanceolate to linear, 3–60 mm long, 1–23 mm wide, margins entire; peduncles and pedicels

ascending to erect retrorsely hairy or not. FLOWERS: calyx lobes broadly ovate, 1.5–3 mm long, 1.4–2 mm wide, apex obtuse to acute, short-cuspidate, glabrous or slightly glandular; corolla funnelform, 8–15 mm long from base to orifice, blue to violet or purple, faintly reddish purple-lined, externally glabrous, internal lower surface sparsely white villous; tube 4–7 mm long; throat gradually inflated, the orifice 3–5 mm wide; stamens included or longer pair slightly exserted, the anther cells navicular, fully dehiscent, 0.8–1.2 mm long, the sides glabrous, sutures papillate; staminode with distal 3–4 mm moderately to densely villous with golden yellow to white hairs to 1 mm long. CAPSULES 4–7 mm long, 3.5–5 mm wide, glabrous. $2n=16$.—dry rocky slopes, sagebrush shrublands, pine-oak and pine woodlands; Mohave Co.; 1100–2000 m; (Feb–) Jun–Aug; range map: Fig. 19X; CO, ID, NV, UT, WY.

In AZ, only known from one collection by Palmer in 1877 at Mokiak Pass in n Mohave Co. Palmer's collections are notorious for inaccurate location information. Glenn Clifton and I have both searched the Mokiak Pass area, have found appropriate habitat, but no *P. watsonii*. *Penstemon watsonii* is known from just n of St. George, UT, about 50 km n of Mokiak Pass.

Penstemon whippleanus A. Gray (for Amiel W. Whipple (1817–1863), western explorer) Whipple's beardtongue.—Perennial herbs; caudex woody. STEMS 1–10(–18), 5–50(–100) cm tall, ascending to erect, proximally glabrous or obscurely puberulent, distally glabrous to glandular-pubescent. LEAVES green, glabrous, papillate, the margins entire or obscurely repand to denticulate; basal and proximal cauline leaves crowded, 12–110 mm long, (5–)10–30(–75) mm wide, the blades ovate to lanceolate or elliptic, the bases tapered to cuneate, petiolate, the apices rounded, acute, or acuminate; cauline leaves 2–4 pairs, 15–105 mm long, 3–15(–50) mm wide, the blades spatulate, elliptic, or lanceolate, short-petiolate to sessile and clasping, the apices rounded to acuminate. THYRSES 2–22(–35) cm long, interrupted, secund, the axes sparsely to densely glandular-pubescent, the verticillasters 1–5(–7), the inflorescence branches (1–)2 per node, 2–5-flowered, the proximal bracts leaflike, lanceolate, 10–100 mm long, 1–32 mm wide, the margins entire or obscurely repand proximally, the apices rounded to acuminate; peduncles and pedicels ascending to erect, glandular-pubescent, the peduncles to 65 mm long, the pedicels 1–8 mm long. FLOWERS: calyx lobes lanceolate, 7–10 mm long, 1–2.2 mm wide, glandular-pubescent, the margins entire to erose, scarious basally, the apices acuminate with blunt tips; corolla ventricose to ventricose-ampliate, strongly bilabiate, 15–20 mm long from base to orifice, brownish purple to bluish violet, sometimes ochroleucous, lavender, or white, white-, lavender-, or purple-lined internally on the lower surface, externally glandular-pubescent, internal lower surface sparsely long white-villous; tube 6–9 mm long; throat abruptly inflated, the orifice 5–12 mm wide, the lower lobes projecting, the upper lobes projecting-spreading; stamens included or longer pair reaching orifice, the anthers spreading, the cells explanate, fully dehiscent, 1–2 mm long, the sides glabrous, the sutures smooth, the septa heights less than one half the width of the cell walls; staminodes 12–23 mm, reaching orifice or exserted, distal 1–3 mm sparsely to densely hairy with flat, white to yellowish hairs to 1 mm long, the tip 0.4–1.1 mm wide, straight to

slightly recurved. CAPSULES 5–13 mm long, 3–6 mm wide, glabrous or glandular-puberulent. SEEDS 1–1.5 mm long, tan to dark brown, angled to slightly rounded. $2n = 16$. [*P. arizonicus* A. Heller, *P. hallii* var. *arizonicus* A. Gray].—Rocky slopes in subalpine forests and meadows, alpine meadows; In AZ, only known from the San Francisco Peaks, Kendrick Peak and Barbershop Canyon, Coconino Co.; 2250–3750 m (7400–12,350 ft); range map: Fig. 14D; Jun–Sep(–Oct); CO, ID, MO, NM, UT, WY.

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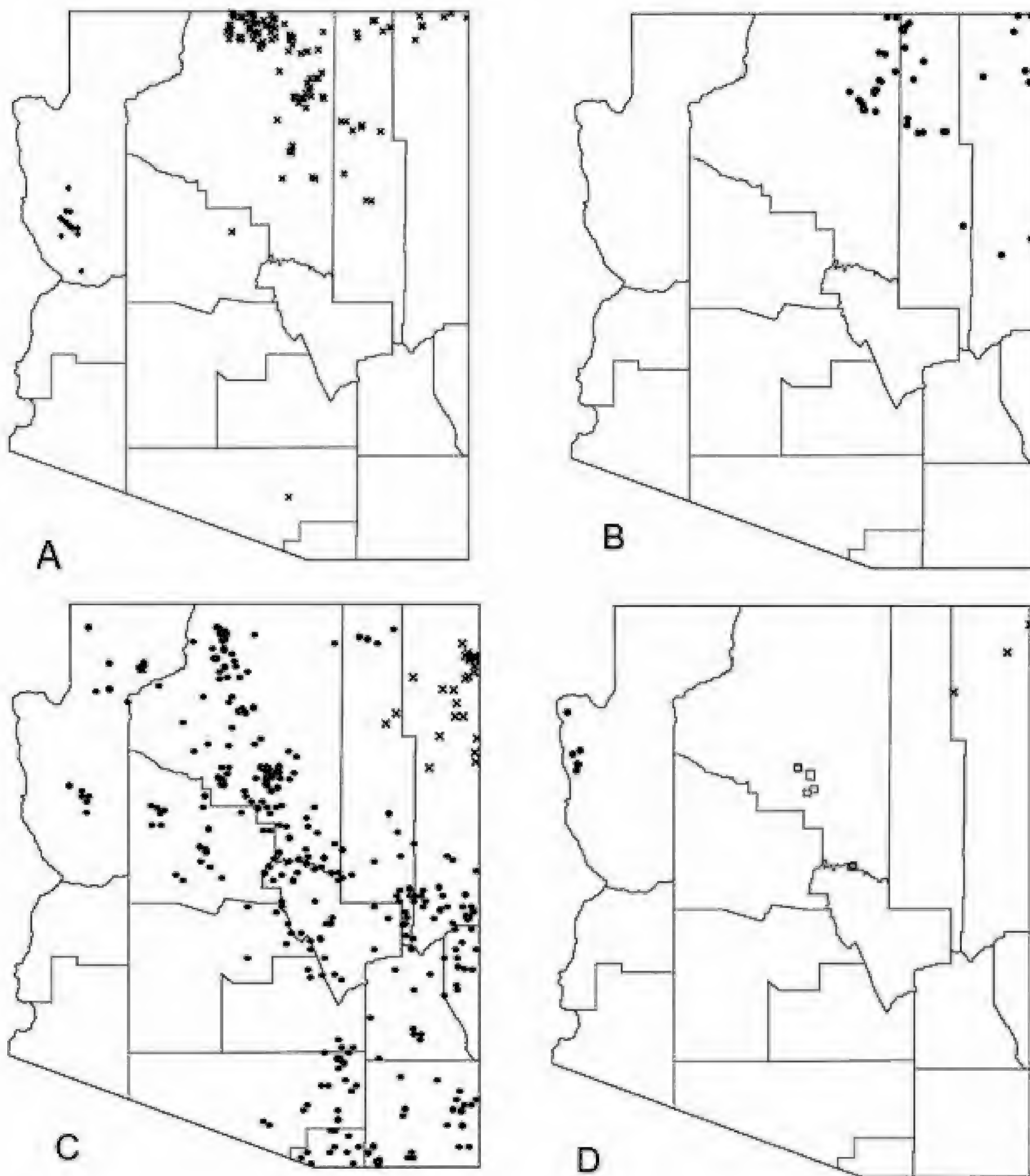
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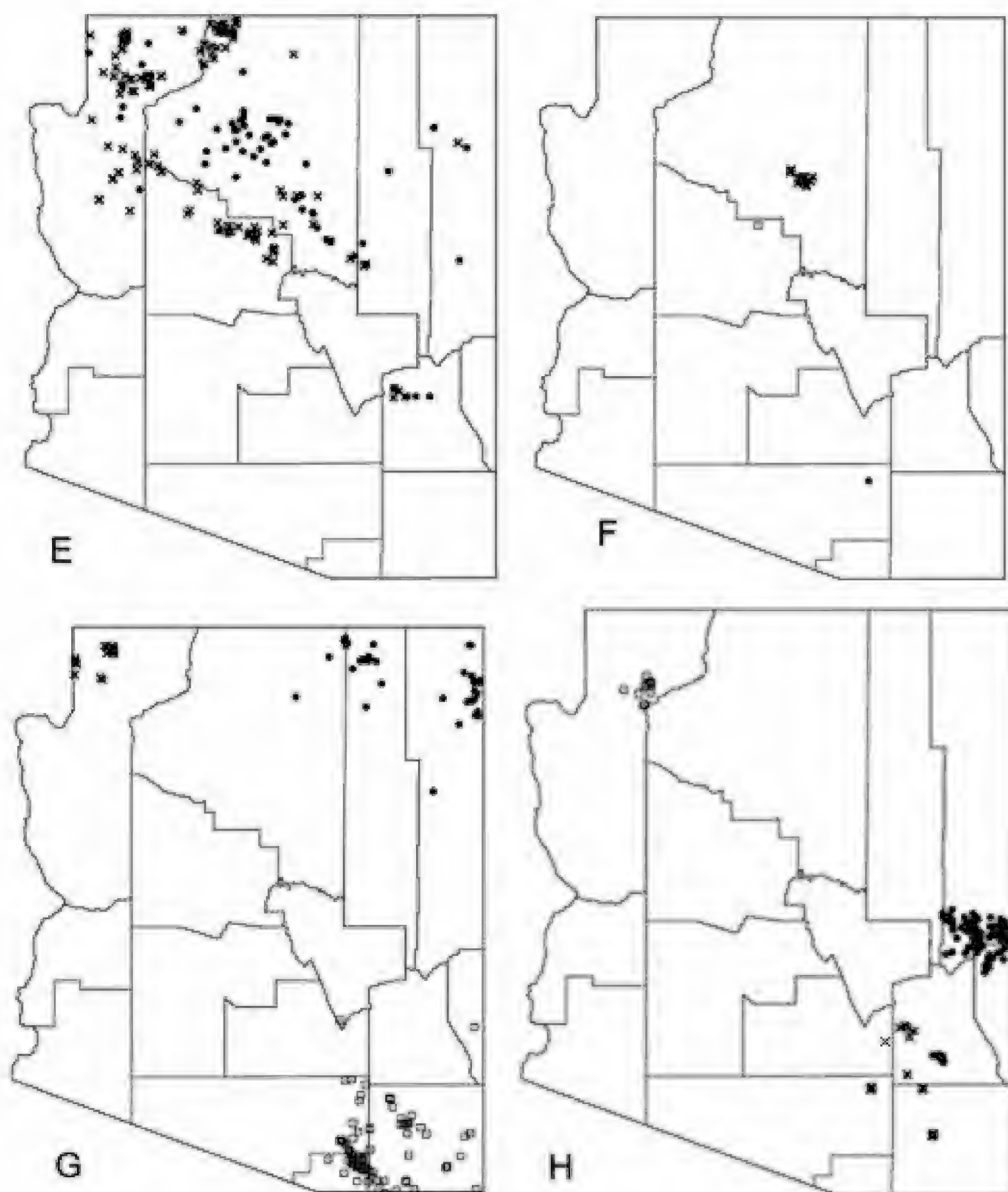
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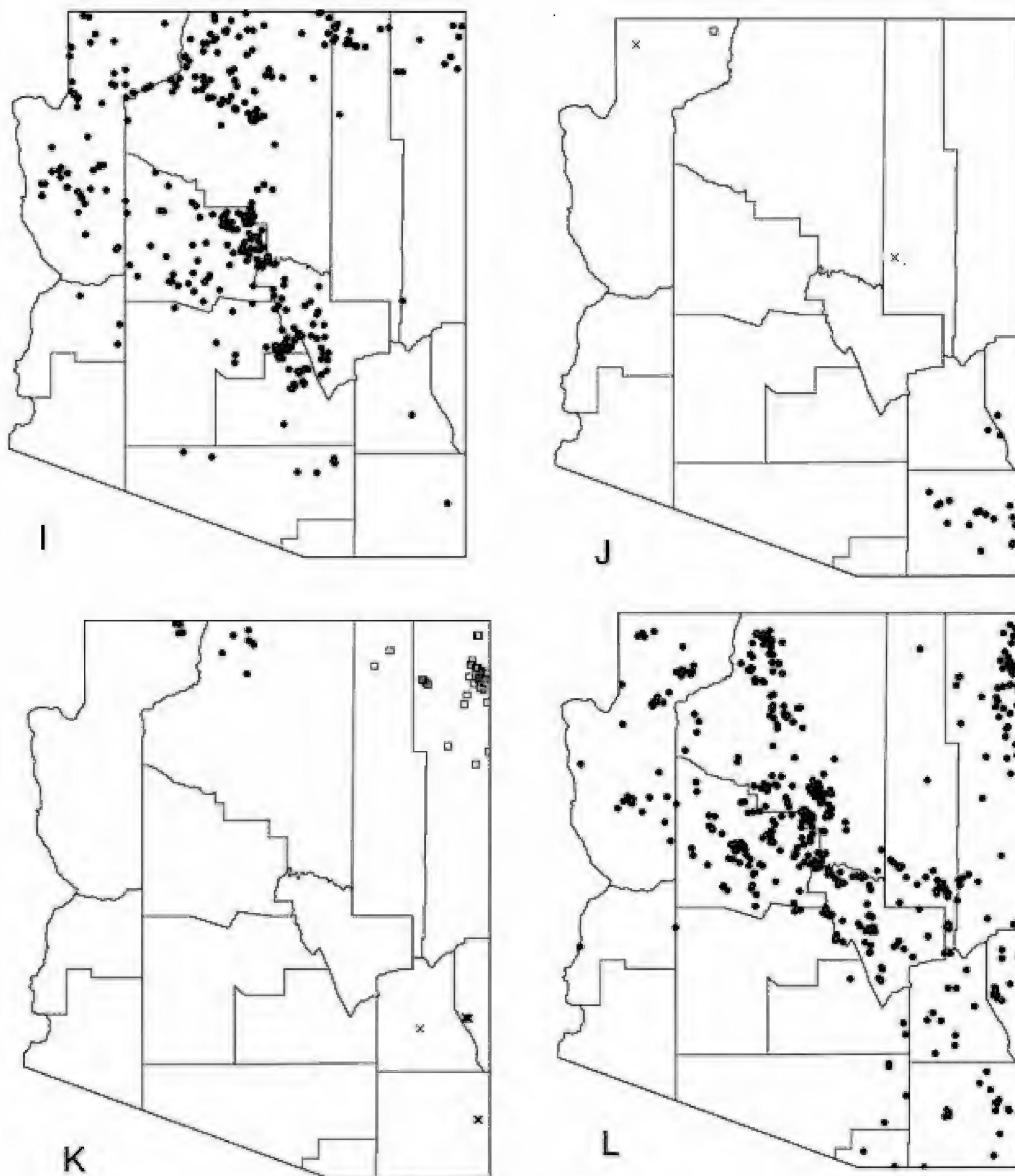
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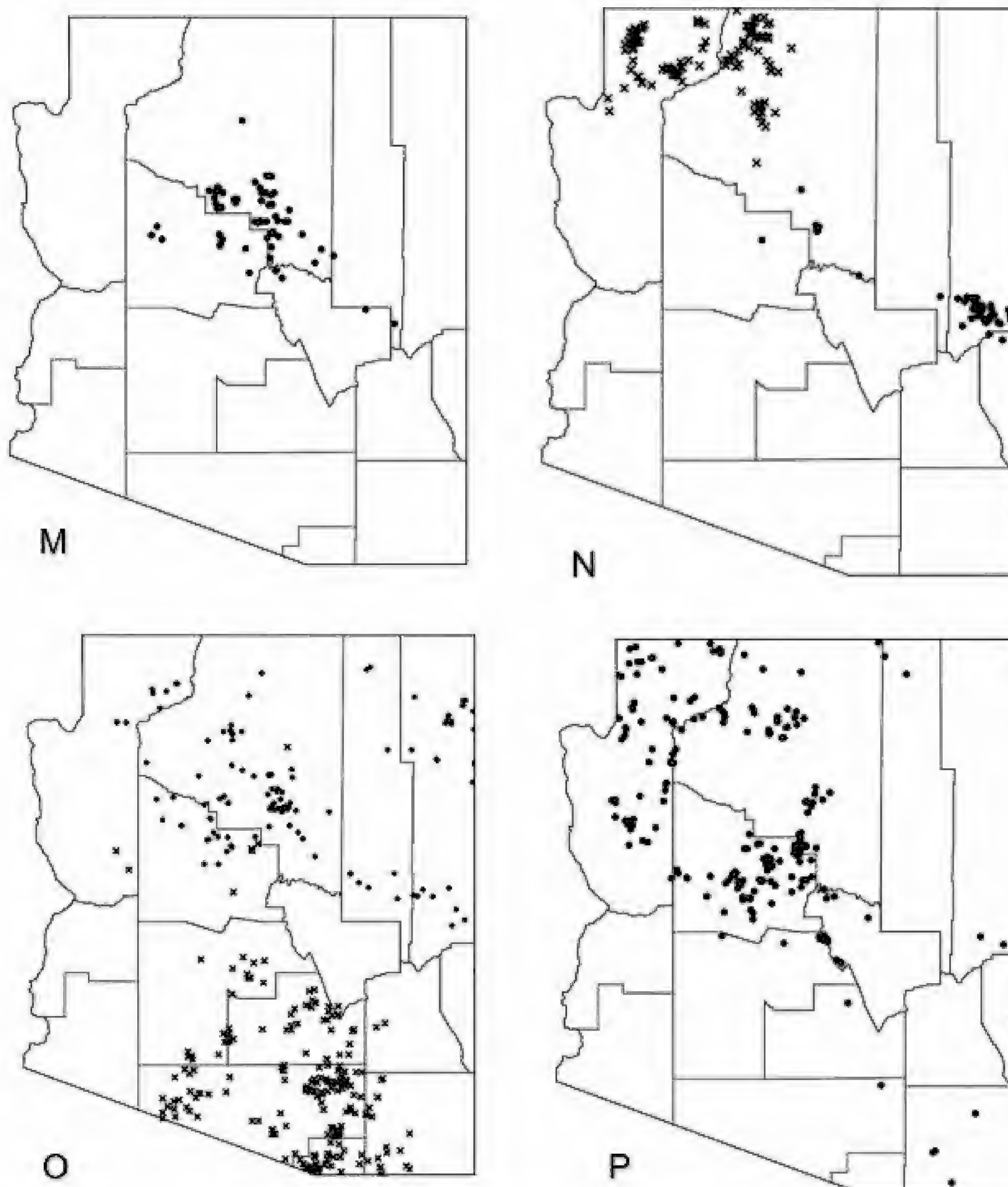
Penstemon Figure 14. Distribution of: (A) • *Penstemon albomarginatus*; × *Penstemon ambiguus*; (B) • *Penstemon angustifolius*; (C) • *Penstemon barbatus*; × *Penstemon trichander*; (D) • *Penstemon bicolor*; × *Penstemon breviculus*, □ *Penstemon whippleanus*



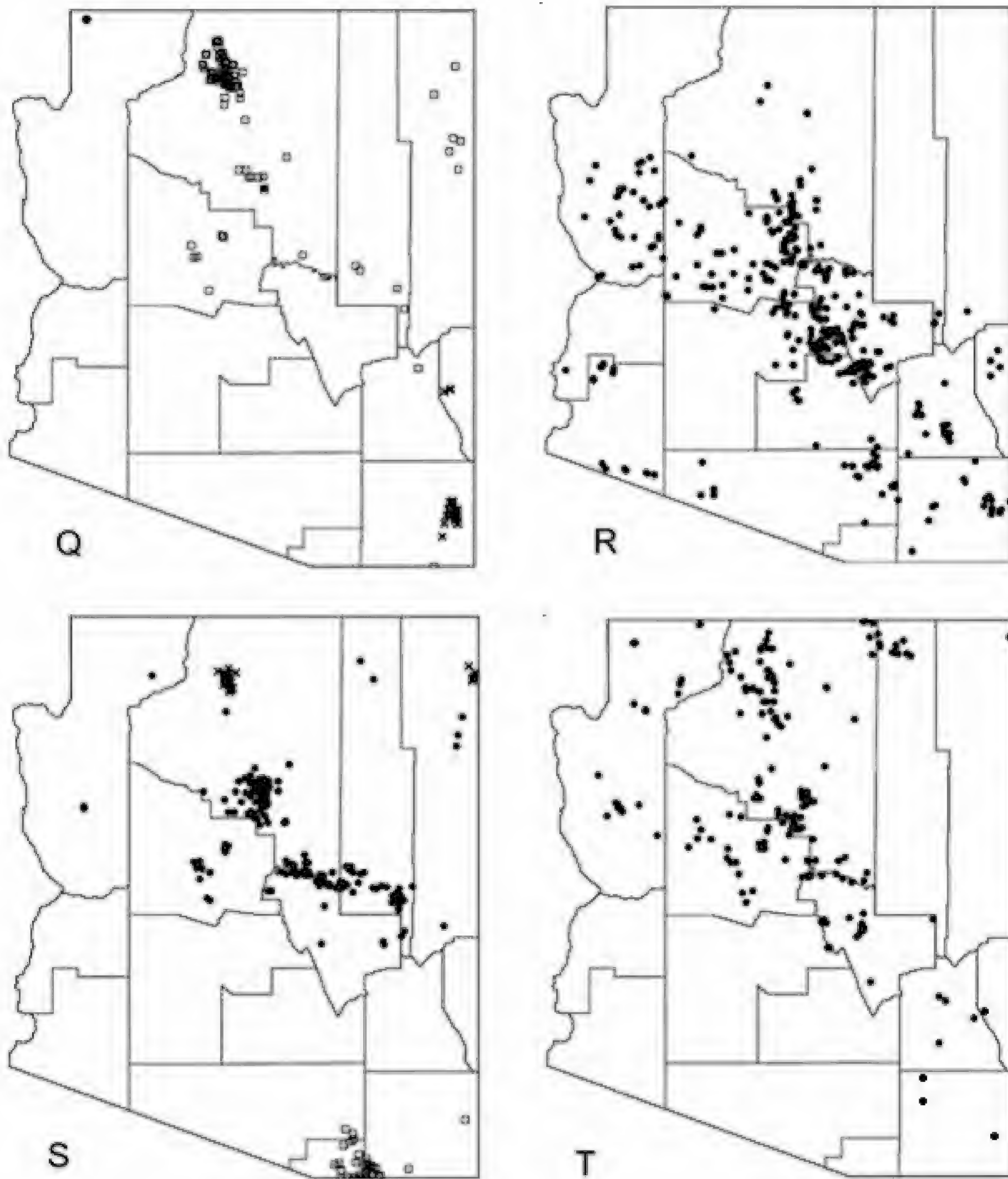
Penstemon Figure 15. Distribution of: (E) • *Penstemon caespitosus*; * *Penstemon thompsoniae*; (F) • *Penstemon centranthifolius*; * *Penstemon clutei*; □ *Penstemon cobaea*; (G) • *Penstemon comarrhenus*; * *Penstemon confusus*; □ *Penstemon dasyphyllus*; (H) • *Penstemon deaveri*; * *Penstemon discolor*; □ *Penstemon distans*



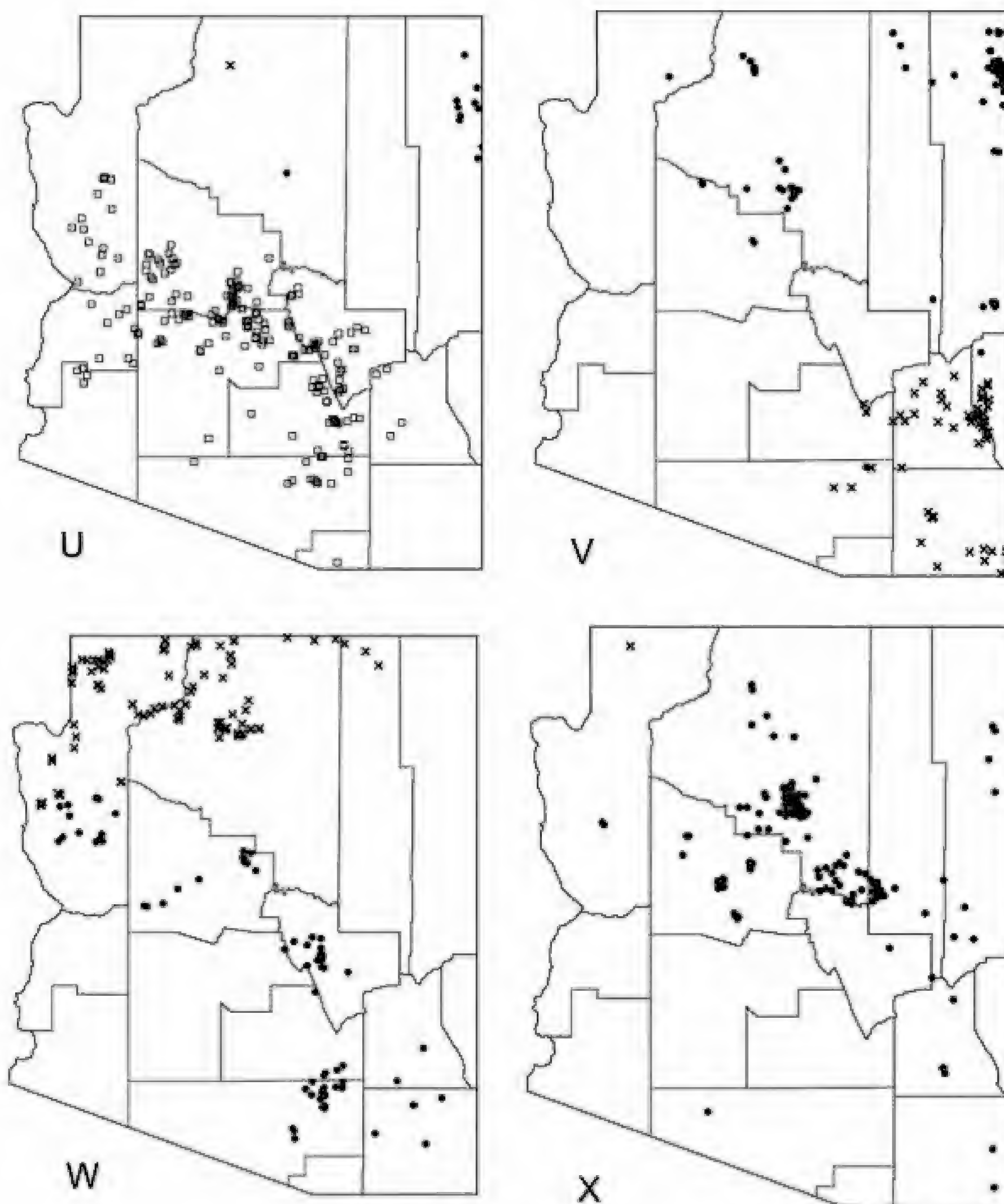
Penstemon Figure 16. Distribution of: (I) • *Penstemon eatonii*; (J) • *Penstemon fendleri*, × *Penstemon higginsii*, □ *Penstemon x jonesii*; (K) • *Penstemon laevis*, × *Penstemon lanceolatus*, □ *Penstemon lentus*; (L) • *Penstemon linarioides*



Penstemon Figure 17. Distribution of: (M) • *Penstemon nudiflorus*; (N) • *Penstemon oliganthus*, × *Penstemon pachyphyllus*; (O) • *Penstemon ophianthus*, × *Penstemon parryi* (P) • *Penstemon palmeri*



Penstemon Figure 18. Distribution of: (Q) • *Penstemon petiolatus*, * *Penstemon pinifolius*, □ *Penstemon pseudoputus*; (R) • *Penstemon pseudospectabilis*; (S) • *Penstemon putus*, * *Penstemon rydbergii*, □ *Penstemon stenophyllus*; (T) • *Penstemon rostriflorus*.



Penstemon Figure 19. Distribution of: (U) • *Penstemon strictiformis*, × *Penstemon subglaber*, □ *Penstemon subulatus*; (V) • *Penstemon strictus*, × *Penstemon superbus*; (W) • *Penstemon thurberi*, × *Penstemon utahensis*; (X) • *Penstemon virgatus*, × *Penstemon watsonii*.



Penstemon deaveri on the Black River, White Mountains, Arizona

Photo: Max Licher

A Visual Guide to Arizona Penstemons

This is an Appendix to the treatment of the genus *Penstemon* for the Vascular Plants of Arizona Project, which includes keys, genus and species descriptions, and range maps. The Visual Guide can be used to help verify an identification and to appreciate the beauty and diversity of *Penstemon* species found in Arizona.



Penstemon albomarginatus

- Perennial herb
- Flowers bluish
- Stems and leaves glabrous or scabrous
- Anthers explanate, glabrous
- Staminode glabrous
- nw AZ, sand

G. Clifton



Penstemon ambiguus

- Large rounded subshrub
- Flowers white or pinkish
- Stems and leaves glabrous or scabrous
- Anthers explanate
- Staminode glabrous
- ne AZ, sand

M. Stevens



Penstemon angustifolius

- Perennial herb
- Flowers pink or blue
- Stems and leaves glabrous
- Anthers navicular
- Staminode: distal 2–3 mm villous with yellow hairs to 1.2 mm
- ne AZ, sand or clay

G. Clifton



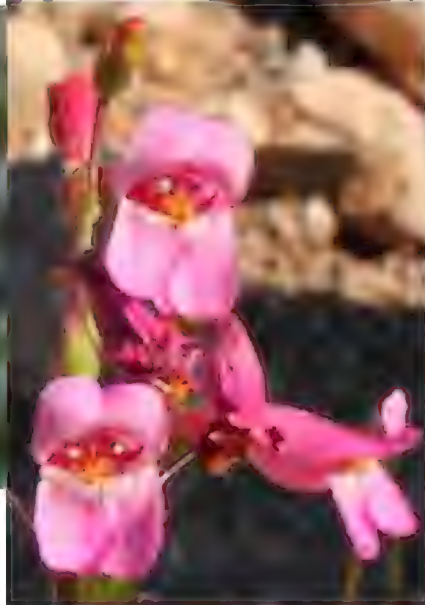
Penstemon barbatus

- Perennial herb
- Flowers red
- Stems and leaves glabrous
- Anthers scoop-shaped
- Staminode glabrous
- widespread

G. Clifton



G. Clifton



Penstemon bicolor

- Perennial herb
- Flowers yellow to pink/purple
- Stems and leaves glaucous
- Anthers explanate
- Staminode distal 4–5 mm w/ yellow hairs to 2.8 mm
- ne AZ, washes

S. Smith



Penstemon breviculus

- Perennial herb
- Flowers blue to violet
- Stems glandular puberulent distally
- Anthers explanate
- Staminode distal 5–7 mm densely pubescent with yellow hairs to 1.4 mm
- ne AZ

M. Stevens



Penstemon caespitosus* var. *desertipicti

- Caespitose subshrub
- Flowers blue
- Stems and leaves retrorse puberulent
- Anthers navicular
- Staminode distal 3–7 mm pilose with golden yellow hairs to 1.2 mm
- Widespread

G. Clifton



Penstemon clutei

- Herbaceous perennial
- Flowers red
- Stems and leaves glaucous
- Anthers explanate
- Staminode glabrous or distal 1–4 mm with white to yellow hairs to 1.4 mm
- San Francisco Volcanic Field

G. Rink



Penstemon comarrhenus

- Herbaceous perennial
- Flowers pale blue
- Stems and leaves glabrous or retrorse puberulent
- Anthers scoop-shaped, connective indehiscent; lanate
- Staminode glabrous or distal 1–2 mm sparsely pilose w/ white hairs to 1 mm
- ne AZ

G. Clifton



Penstemon confusus

- Herbaceous perennial
- Flowers violet to purple
- Stems and leaves glabrous
- Anthers explanate to open-ended navicular
- Staminode distal 1–2 mm papillate with golden yellow papillae to 0.2 mm, or glabrous
- nw AZ

M. Stevens



Penstemon dasyphyllus

- Basally woody
- Flowers blue
- Stems and leaves puberulent
- Anthers navicular-bulging
- Staminode glabrous
- se AZ

J. Cowles



Penstemon deaveri

- Basally woody
- Flowers purple
- Stems and leaves puberulent
- Anthers open-ended navicular
- Staminode hairy
- e AZ

G. Clifton



Penstemon discolor

- Subshrub
- Flowers blue (white)
- Stems and leaves glabrous (mostly)
- Anthers navicular
- Staminode hairy
- se AZ

T. Embrey



Penstemon distans

- Basally woody
- Flowers blue
- Stems and leaves glandular puberulent
- Anthers navicular
- Staminode hairy
- nw AZ

G. Clifton



Penstemon eatonii

- Basally woody
- Flowers red
- Stems and leaves hairy or not
- Anthers saccate
- Staminode glabrous or hairy
- throughout AZ

M. Licher



Penstemon fendleri

- Basally woody
- Flowers bluish
- Stems and leaves glabrous
- Anthers navicular
- Staminode hairy
- se AZ

P. Alexander



Penstemon higginsii

- Basally woody, highly branched
- Flowers bluish
- Stems and leaves glabrous
- Anthers saccate
- Staminode glabrous
- nw AZ

G. Clifton



Penstemon xjonesii

- Basally woody
- Flowers bluish to reddish
- Stems and leaves glabrous to hairy
- Anthers scoop-shaped
- Staminode hairy
- nw AZ

R. Johnson



Penstemon laevis

- Basally woody
- Flowers bluish to reddish
- Stems and leaves glabrous
- Anthers scoop-shaped
- Staminode hairy
- nw AZ

M. Stevens



Penstemon lanceolatus

- Basally woody
- Flowers red
- Stems and leaves hairy
- Anthers navicular-bulging
- Staminode glabrous
- se AZ

P. Alexander



Penstemon lentus

- Basally woody
- Flowers blue
- Stems and leaves glabrous
- Anthers open-ended navicular
- Staminode hairy
- ne AZ

G. Clifton



Penstemon linarioides

- Basally woody
- Flowers blue
- Stems and leaves hairy
- Anthers navicular
- Staminode hairy
- widespread

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Penstemon nudiflorus

- Basally woody
- Flowers blue
- Stems and leaves glabrous
- Anthers open-ended navicular
- Staminode hairy
- Central AZ

M. Licher



Penstemon oliganthus

- Perennial herb
- Flowers blue
- Stems and leaves hairy
- Anthers navicular
- Staminode hairy
- Central & e AZ

G. Clifton



Penstemon ophianthus

- Perennial herb
- Flowers purplish, rarely white
- Stems glandular puberulent
- Anthers explanate
- Staminode distal 8–9 mm densely pubescent with yellow hairs to 2.4 mm
- n AZ

M. Licher



Penstemon pachyphyllus

- Basally woody
- Flowers blue
- Stems and leaves glabrous
- Anthers open-ended navicular
- Staminode hairy
- nw AZ

M. Stevens



Penstemon palmeri

- Basally woody
- Flowers white to rose
- Stems and leaves glabrous
- Anthers navicular or explanate
- Staminode hairy
- widespread

G. Clifton



Penstemon parryi

- Basally woody
- Flowers magenta to scarlet
- Stems and leaves glabrous
- Anthers explanate
- Staminode hairy
- widespread

P. Alexander



Penstemon petiolatus

- Subshrub
- Flowers magenta to scarlet
- Stems and leaves glabrous to hairy
- Anthers explanate
- Staminode hairy
- nw AZ

M. Stevens



Penstemon pinifolius

- Subshrub
- Flowers scarlet
- Stems and leaves glabrous to hairy
- Anthers explanate
- Staminode hairy
- se AZ

P. Alexander



Penstemon pseudoputus

- Basally woody
- Flowers blue to purple
- Stems and leaves hairy
- Anthers open-ended navicular
- Staminode glabrous
- Mostly n central AZ

G. Clifton



Penstemon pseudospectabilis

- Basally woody
- Flowers rose-pink
- Stems and leaves glabrous
- Anthers explanate
- Staminode glabrous to hairy
- Widespread

G. Clifton



Penstemon putus

- Basally woody
- Flowers blue to white
- Stems and leaves glabrous
- Anthers open-ended navicular
- Staminode glabrous
- Mostly central AZ

G. Clifton



Penstemon rostriflorus

- Basally woody
- Flowers orange to scarlet
- Stems and leaves mostly glabrous
- Anthers saccate
- Staminode glabrous
- Widespread

G. Clifton



Penstemon rydbergii

- Basally woody
- Flowers blue to purple
- Stems and leaves glabrous or hairy
- Anthers navicular
- Staminode hairy
- Kaibab Plateau and Chuska mtns

M. Stevens



Penstemon stenophyllus

- Basally woody
- Flowers violet to blue
- Stems and leaves glabrous or hairy
- Anthers navicular-bulging
- Staminode glabrous
- s AZ

P. Alexander



Penstemon strictiformis

- Basally woody
- Flowers lavender to blue
- Stems and leaves glabrous to puberulent
- Anthers scoop-shaped
- Staminode hairy
- ne AZ

M. Stevens



Penstemon strictus

- Basally woody
- Flowers blue to purple
- Stems and leaves glabrous
- Anthers scoop-shaped
- Staminode hairy
- Native: ne AZ; widely introduced

P. Alexander



Penstemon subglaber

- Basally woody
- Flowers blue to purple
- Stems and leaves glabrous to puberulent
- Anthers scoop-shaped
- Staminode hairy
- Kaibab Plateau, introduced

M. Stevens



Penstemon subulatus

- Basally woody
- Flowers red
- Stems and leaves glabrous
- Anthers exsertate
- Staminate glabrous
- Below the Mogollon Rim

G. Clifton



Penstemon superbus

- Basally woody
- Flowers red
- Stems and leaves glabrous
- Anthers exsertate
- Staminate hairy
- s of the Mogollon Rim

P. Alexander



Penstemon thompsoniae

- Basally woody
- Flowers blue
- Stems and leaves hairy
- Anthers navicular
- Staminate hairy
- Widespread

G. Clifton



Penstemon thurberi

- Herbaceous to shrubby
- Flowers white to blue
- Stems and leaves glabrous
- Anthers exserted to navicular
- Staminate glabrous
- s & w of the Mogollon Rim

G. Clifton



Penstemon trichander

- Basally woody
- Flowers red
- Stems and leaves hairy
- Anthers scoop-shaped
- Staminate glabrous
- n AZ

M. Stevens



Penstemon utahensis

- Basally woody
- Flowers red
- Stems and leaves glabrous
- Anthers exserted to navicular
- Staminate glabrous
- AZ Strip, mostly

G. Clifton



Penstemon virgatus

- Basally woody
- Flowers blue-ish
- Stems and leaves mostly hairy
- Anthers open-ended navicular
- Staminode glabrous
- c AZ, w/ outliers

M. Licher



Penstemon watsonii

- Basally woody
- Flowers blue-ish
- Stems and leaves hairy or not
- Anthers navicular
- Staminode hairy
- AZ Strip

G. Clifton



Penstemon whippleanus

- Basally woody
- Flowers blue-ish
- Stems and leaves mostly glabrous
- Anthers explanate
- Staminode hairy
- SF Peaks, Mogollon Rim

M. Stevens